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YOUR EXPERT GUIDE TO
TODAY'S TECH

JUNE 2021 #494



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CULTURAL ICON



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THE APC SUB-\$600
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LANGUAGE

DUOLINGO VS. BABBEL

BEST APPS
COMPARED



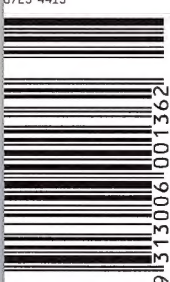
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HOW TO
PROFIT
WITHOUT
MINING

GET ONBOARD WITH CRYPTO

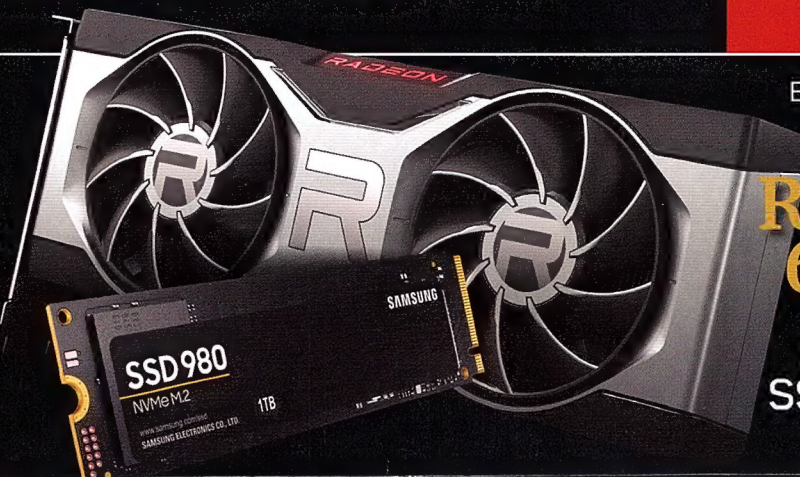
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Vigor2865 Series

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Vigor2865Vac

32x
VPN

- Multi-WAN with 1 x VDSL2 35b Supervectoring/ADSL2+ WAN port, 1 x configurable GbE WAN/LAN port, 2 x USB ports and 2 x Wi-Fi WANs (ac/Vac models)
- 1 x XDSL port and 1 x configurable GbE WAN/LAN port for Failover, Load Balancing and High Availability mode
- 2 x USB 2.0 ports for 3G/4G LTE USB modems, FTP server, network printer or thermometer
- 5 x Gigabit LAN ports with multiple subnets and 60,000 NAT sessions
- 32 x VPN tunnels (including 16 x OpenVPN/SSL-VPN tunnels) with most security protocols
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- Integrated IEEE 802.11ac wireless Access Point; dual band; up to 867 Mbps throughput (ac/Vac model)
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- VoIP (2 x FXS and 1 x FXO Line Port) for Vigor2865Vac
- Support VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- SD WAN capability when used with VigorACS 3
- Central VPN Management for up to 8 remote Vigor routers
- Central AP Management for up to 20 Vigor Access Points
- Central Switch Management for up to 10 VigorSwitches
- 2 years back to base warranty

Vigor2765 Series

VDSL2 35b/ADSL2+ routers with 1 x configurable GbE WAN/LAN port, 3 x GbE LAN ports, SPI Firewall, 802.11ac Wi-Fi, and 2 x VPN tunnels including 2 x SSL-VPN



Vigor2765Vac

2x
VPN

- 1 x VDSL2 35b/ADSL2+ WAN port
- 35b Supervectoring VDSL2
- 1 x configurable GbE WAN/LAN port (P4)
- 3 x Gigabit Ethernet LAN ports with 50,000 NAT sessions
- 2 x USB ports for 3G/4G LTE mobile broadband access, USB printer and storage
- Object-based SPI Firewall, CSM (Content Security Management) and QoS for network security
- IPv6 & IPv4
- 2 x VPN tunnels including 2 x SSL-VPN tunnels
- IPsec VPN throughput at 200 Mbps (AES 256 bits)

- Integrated IEEE 802.11ac wireless Access Point (Vac/ac model)
- 2 x FXS VoIP (Vac model)
- Support VigorACS 2 Central Management System for remote management
- Central AP Management for up to 2 Vigor Access Points
- 2 years back to base warranty

Vigor130

VDSL2/ADSL2+ modem/router with 1 x GbE LAN port and SPI Firewall



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- 1 x Gigabit Ethernet LAN port
- VDSL2 vectoring
- Bridging for VDSL2 and ADSL2+
- Object-oriented SPI Firewall
- IPv6 & IPv4
- Supports VigorACS 2 Central Management System for remote management
- 1 years back to base warranty



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INTRO

EDITORIAL

WELCOME TO ANOTHER ISSUE OF APC



EDITORIAL

Winning

Rewarding the good stuff.

Right now I'm immersed in my favourite part of this job – along with the rest of the team we're putting together our annual Australian PC Awards.

The best thing about PC tech has always been the extraordinary pace of innovation and technological advancement. Every single month we're served up evolutions of existing products, or brand new gear that raises the bar (hopefully!) once again. It's not always easy to keep abreast of the vast landscape of tech that the PC encompasses, and that's why the APC team is a collection of expert know-it-alls across a range of areas.

I think you probably appreciate their skills, and how well they explain things as you digest our magazine articles and reviews. So, once again, we have asked the team to distill the many new products we've seen over 2020 and into the first quarter of 2021 into a tight set of finalists, and ultimately, winners.

Daily, for weeks now, we've been slowly and steadily backtracking over the gear that went on sale in Australia during that period. And we're at the point, now, where we have it all gelled into a list of best of the best gear that we can confidently say deserves the highest accolades. Our next job – choose the winners!

The Award categories we have nicely reflect what you read about in APC. There's the always exciting CPU categories, which were traditionally a Red v Blue battleground, but now have a new contender with Apple's M1 having made its spectacular entry into that scene. GPUs stick with the traditional and now very even Nvidia vs AMD head to head – though this time next year it may well see Intel enter the game.

Across all the important components we've seen outstanding products that were often very difficult to judge. The motherboards category in particular sure is a tight contest, while the year in laptops has seen some startling leaps that were as surprising as they were pleasing.

A cool and fun category to compile were the many peripherals areas. Seeing all the little evolutions stack up in mice and laptops over the year always puts a smile on our faces. The most intense debate amongst the team, though, was considering the Excellence award. That one goes to the 'person, product or technology that advanced the PC more than any other'. It's our Gold Logie and oh boy it's been a fascinating one to discuss, as we engaged our deepest thought mode and properly compared things from often vastly different areas.

All the finalists and winners will be revealed in the next issue – and more excitingly, you can tune in to watch the video broadcast on the evenings of June 23, 24 and 25, featuring the APC editorial team! Goto: www.australianpcawards.com.au to see it all, and if you can't watch it live you can view it any time later. **EXCITING!**

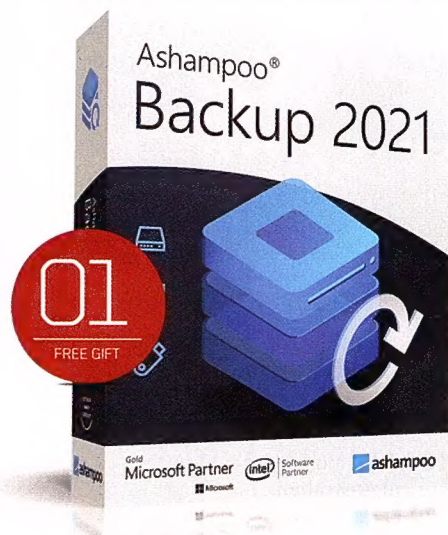
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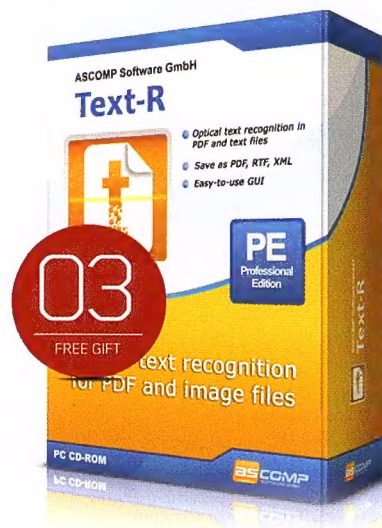


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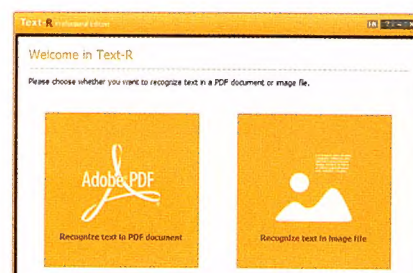


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SAPPHIRE



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GET ONBOARD WITH **CRYPTO** MAKE YOUR PC MAKE MONEY



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APC HOT PRODUCT

When a reviewed product scores 4.5 out of 5 or higher, it carries the Hot Award. These are products that exceed expectations and deliver a quality experience up there with the very best.



APC RECOMMENDS

You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

Inside APC

Find out all about APC's editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a

single brand's products and use a variety of devices. And, like you, APC's journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in APC are not shared

with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an APC reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in APC, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred. ■

APC testbed

The current APC testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	MSI GeForce RTX 3080 Gaming X Trio
Memory	2x8GB Team T-Force Xtream ARGB DDR4-3600
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000

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VESA: DisplayHDR 2000 doesn't exist

Recalibrate your expectations.

VESA released a statement denying recent claims that two monitors are "DisplayHDR 2000" certified because, well, there's no such thing as DisplayHDR 2000. The statement was issued in response to listings on Taobao, a popular Chinese retailer, for an updated Samsung Odyssey G9 and a new Acer EI491CRG9 monitor.

VESA said that it "has no knowledge of the origins of the DisplayHDR 2000 logo currently posted on these display listings," adding that it "takes any misuse of our trademarks and logos seriously," which suggests the logos won't be there long. A DisplayHDR 2000 certification probably isn't going to debut any time soon, if only because it would be awkward for VESA to release such a strongly worded statement about these logos right before the new certification is officially revealed.



Alienware launches its first AMD laptop since 2007

M15 Ryzen Edition R5 breaks a long Intel dominance.

Alienware is releasing its first laptop with an AMD CPU since 2007. Its parent company, Dell, announced the Alienware m15 Ryzen Edition R5 laptop in April.

The Alienware m15 Ryzen Edition R5 will use AMD's Ryzen 5000 H-series chips paired with Nvidia GeForce RTX 30-series GPUs. Like the Asus ROG Zephyrus Duo 15 SE, it will go up to a Ryzen 9 5900HX. The new m15 Ryzen Edition R5 will also be the first 15-inch Alienware laptop going to DDR4 memory at 3,200 MHz, and that memory will be user-replaceable.

The last Alienware laptop to pair with an AMD CPU and an Nvidia GPU was the Aurora mALX, last seen in 2007.



CHIPS

Report claims Apple's latest 'M2' chips are in mass production

CPUs for new MacBook and iMac lines on their way.

Apple's successor to the M1 chip, commonly referred to as the M2, has now entered mass production, better positioning the tech giant in its goal of completely replacing Intel chips in Macbooks with its own bespoke hardware.

Reported by *Nikkei Asia*, the Apple M2 could be integrated into consumer products like the MacBook Air and MacBook Pro 13-inch from July onwards, meaning interested consumers should look towards the latter half of the year for MacBooks with improved specs.

It's noteworthy that the M2 is likely to be a different chip than the rumoured M1X, which is said to be a more powerful, business-oriented processor tailor-made for specialist computers like the Mac Pro and MacBook Pro 16-inch.

Apple's M2 would come hot on the heels of the M1 SoC (System on Chip), the company's first bespoke processor for both Mac and now iPad Pro devices. The M1 was an impressive first attempt from Apple, boasting improvements over the Intel chips the company was using prior, so it's easy to imagine the company will be aiming to push the envelope even further with the M2 chip.

Apple's M series of chips combine several components into one, providing central processing, graphical processing

and AI enhancing capabilities all on one chip. The tech giant's M1 chip already had improved performance and efficiency over its closest competitors, being Intel Core and AMD Ryzen processors, in a number of our benchmarks, so we're eager to see how Apple can continue that momentum with both the M2 and M1X chips.

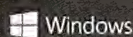
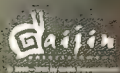
With two new chipsets rumoured to be on the way, then, consumers can potentially look forward to more bespoke hardware releasing from Apple in the near future. While the new chips might not reach the dizzying graphical heights provided by Nvidia's GeForce RTX 30 series, in terms of professional and productivity usage, Apple's M2 and M1X chips may well have an edge over the competition.

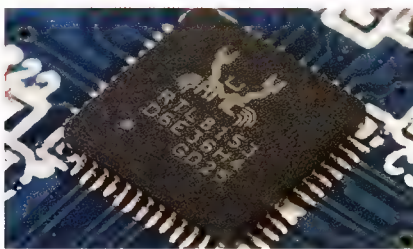
Apple is currently the world's fourth largest PC maker, after Lenovo, HP, and Dell, with a market share of 7.6 percent in Q4 2020. Its switch to the ARM-based M-series chips came in 2020 after 15 years of using Intel chips in its Macs. Before that, in 1994, Apple had switched to IBM's PowerPC architecture, having used the Motorola 68000 since the Mac's inception in 1984. The company expects to take two years to fully transition its range to the new SOCs.

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Realtek chip shortage hits More bad news for the PC and components market.

It seems that Realtek has joined the long list of supply chain bottlenecks. *DigiTimes* has reported that the company is struggling to meet demand for the various chips manufacturers use in their notebooks, automobiles and other kinds of devices.

In the story, *DigiTimes* remarked that Realtek has extended its delivery lead times to 32 weeks as the capacity of the foundries is currently tight and there are shortfalls in the supply of the necessary raw materials.

Those chips are found in a wide variety of products. The audio+LAN chips are used in notebooks, for example, and the xDSL chips are being used in "smart city projects" by Samsung. But the shortage of networking equipment might be most worrisome.



Hard drive and SSD shortages could be imminent If new cryptocurrency blooms.

With the emergence of the Chia cryptocurrency, miners in China are reportedly frantically snatching up every hard drive and SSD they can find. Unlike other cryptocurrencies, you don't mine Chia with a processor, graphics card or ASIC miner. Instead, you farm Chia with storage space, which is where hard drives or SSDs come in.

Unlike Bitcoin, which is based on proof of work, Chia utilises a proof of space and time model. Chia reportedly arrives as an eco-friendly cryptocurrency. Bram Cohen, who's best known as the inventor of BitTorrent, created Chia to leverage the free space on storage devices. The basis behind Chia is that hard drives and SSDs use less power, are easier to come by and cheaper to purchase.



Pic: Getty Images

THREATS

Intel, Microsoft team up to combat cryptojacking

Beefing up Microsoft Defender for Endpoint.

Intel and Microsoft are collaborating on a new project to help enterprise and small business customers avoid security issues that may involve others using PCs on your network to mine cryptocurrencies, known as cryptojacking.

The protection will be built into Microsoft Defender for Endpoint on systems using 6th Gen or later Intel vPro and Intel Core processors. Specifically, it uses Intel Threat Detection Technology, or TDT to take advantage of the CPU for machine learning to detect cryptomining.

Intel stated that the rise of cryptocurrencies in the mainstream and

their increase in value means that "cybercriminals [will] shift their focus from ransomware to cryptojacking." Intel claims that there was a 53 percent increase in mining malware attacks in the fourth quarter of 2020 compared to the quarter before it.

Cryptojacking, just like normal cryptomining, weighs heavily on a computer's resources and sends the crypto back to a wallet. This could drastically slow a computer. Intel suggests some cryptojackers can also spread over a network, where large businesses could have hundreds or thousands of devices.

Arm-powered Grace CPU from Nvidia debuts

Nvidia comes for the data centre CPU market.

Nvidia introduced its Arm-based Grace CPU architecture that it says delivers 10X more performance than today's fastest servers in AI and HPC workloads. The new chips will soon power two new AI supercomputers and come powered by unspecified "next-generation" Arm Neoverse CPU cores paired with LPDDR5x memory that pumps out 500 GBps of throughput, along with a 900 GBps NVLink connection to an

unspecified GPU for the leading-edge devices.

Nvidia also revealed a new roadmap that shows a "Grace Next" CPU coming in 2025, along with a new "Ampere Next Next" GPU that will arrive in mid-2024. Nvidia's pending Arm acquisition, which is still winding its way through global regulatory bodies, has led to plenty of speculation that we could see Nvidia-branded Arm-based CPUs. ■

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TECH BRIEF

Microsoft uses boiling liquid to cool data center servers

Boiling Liquid promises to be better in every way compared to air cooling.

It probably won't make the list of best CPU coolers for end users anytime soon, but Microsoft's data centre servers could be getting a massive thermal management upgrade in the near future. Right now, the software giant is testing a radical new cooling technology known as boiling liquid, which promises to be higher performance, more reliable, and cheaper to maintain compared to traditional air cooling systems in data centres right now.

Servers that are equipped with this new prototype cooling system look very similar to mineral oil PCs if you've seen one. Dozens of server blades are packed tightly together in a fully submerged tank of boiling liquid. The liquid of course is non-conductive so the servers can operate safely inside the liquid environment.

The liquid is a special unknown recipe that boils at 50 degrees Celsius. The low boiling point is needed to drive heat away from critical components. Once the liquid begins boiling, it'll automatically roll up to the surface, allowing cooled condensers to contact the liquid, returning the cooling liquid to its fully liquidised state.

Effectively, this system is one

gigantic vapour chamber. Both cooling systems rely on chemical reactions to bring heat from system components to cooling chambers, whether that be heatsinks or, in this case, a condenser.

Death of Moore's Law is to blame

Microsoft's says that it is developing such a radically new cooling technology is because of the rising demands of power and heat from computer components, which are only going to get worse. The software giant claims that the death of Moore's Law is to blame for this; transistors on computer chips have become so small that they've hit the atomic level. Soon you won't be able to shrink the transistors on a new process node any smaller as it will be physically impossible to do so.

To counter this, chip fabs have had to increase power consumption quite significantly to keep increasing CPU performance – namely from adding more and more cores to a CPU.

Microsoft took inspiration from the datacenter server clusters operating on seabeds when developing the new

Boiling liquid carries away heat generated by computer servers at a Microsoft datacentre. Microsoft is the first cloud provider to run two-phase immersion cooling in a production environment.

cooling technology. A few years ago Microsoft unleashed Project Natick, which was a massive operation to bring datacentres underwater to inherit the benefits of using seawater as a cooling system.

To do this, the server chambers were filled with dry nitrogen air instead of oxygen and use cooling fans, a heat exchanger, and a specialised plumbing system that pipes in seawater through the cooling system. What Microsoft learned was the sheer reliability of water/liquid cooling. The servers on the seafloor experienced one-eighth the failure rate of replica servers on land with traditional air cooling. Analysis of the situation indicates the lack of humidity and corrosive effects of oxygen were responsible for the increased sustainability of these servers.

Microsoft hopes its boiling liquid technology will have the same effects. If so, we could see a revolution in the data centre world where servers are smaller, and much more reliable. Plus with this new cooling system, server performance is hopefully increased as well. ■

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END USER

The loot box controversy looks set to ramp up once again

The gambling system has been demonised but it still lingers in some of the world's biggest games, writes Shaun Prescott.

Loot boxes in videogames aren't a new phenomenon, and predate even those titles most strongly associated with them – *Overwatch*, *Counter-Strike*, *FIFA*, *Star Wars Battlefront 2*. But it's fair to say that those games have helped propel them into the public consciousness, in a way the industry may not have intended. In the plainest sense loot boxes are gambling. It usually works like this: while regular gameplay can net the player loot boxes filled with randomised cosmetic goods, it's also possible to buy them in packs that are also randomised. You're not paying for a product; you're paying for the chance to win the product.

Some players love them, like children love Kinder Surprises. A lot of players hate them. Over the past four years the matter of loot boxes has burst outside the gamer niche, with some countries going so far as to impose regulations: in China purchasable loot boxes need to declare their contents, thus somewhat eliminating the point of them. In the Netherlands, if a loot box has some kind of market value it's forbidden, likewise in Belgium. In Australia and Germany, new rating requirements have been brought in, warning consumers of

any loot box shenanigans (in Australia, purchasers are warned of the presence of "in-game purchases").

That change was introduced quietly last year, following a 2018 senate inquiry report into loot boxes (or "gaming micro-transactions for chance-based items," in its words). That report recommended a review be launched in order to assess the phenomenon's potential for "gambling-related harms". As of time of writing, *Four Corners* is set to air its own investigation into loot boxes in the Australian context (it's on iView now, if you want to watch it and report back from the future).

But despite the seeming consensus that loot boxes just aren't that great, whether from a health point of view or a "fun" one, some game publishers are hellbent on implementing them. According to leaked documents seen by the CBC, Electronic Arts hoped to funnel players of *FIFA 21* into its microtransaction laden *FIFA Ultimate Team* mode. "FUT is the cornerstone and we are doing everything we can to drive players there," the document reportedly reads. This follows a class action lawsuit filed last year accusing it of



SHAUN PRESCOTT

Author, PC Gamer editor and passionate technology observer, Shaun covers trending tech topics for APC.

running "an unlicensed, illegal gaming system through their loot boxes." EA responded to the CBC report by calling it "a sensationalized story with a misrepresentation of the facts".

But it's definitely a fact that people are spending money on FUT: according to an analyst at NIKO Partners FUT has made EA \$1.49 billion since 2015. And it's increasingly common to see reports about players spending inordinate amounts on the game: one example is a BBC report about a father whose children had been bitten by the bug. "They spent £550 and they still never got their favourite player, Lionel Messi," he said.

EA seems particularly hawkish on the matter of loot boxes – naturally so, as it's making the company a tonne of cash. But whole swathes of the games industry have sworn them off, with a game's lack of loot boxes or their equivalent often popping up as a selling point in marketing material or pre-release hype. With a lot of live service games pivoting to the more benign Battle Pass format in order to keep the cash flowing in, vendors of loot box strewn software are starting to look a tad like the tobacco industry. ■

Facebook wants you to quit whining about its 533 million account data leak

Been getting more spam calls in the last few months? It's probably Facebook's fault and the company wants you to get used to the idea that it'll happen again.

Facebook made a mistake in April when a Belgian PR rep for the company accidentally sent a journalist a copy of an internal memo that detailed the company's intent to 'normalise' its massive 2019 data breach. When Facebook was contacted for comment by *The Register* on the 533 million person account info leak that was uploaded for free on the dark web early in April 2021, the company responded, "This is old data that was previously reported on in 2019" with a Facebook spokesperson adding that "We found and fixed this issue in August 2019". When Brussels reporter Pieterjan van Leemputten asked Facebook the same question, however, he got a more blunt, and less intentional, response that outlined Facebook's PR strategy on the issue "Longer term, though, we expect more scraping incidents and think it's important to both frame this as a broad industry

issue and normalise the fact this activity happens regularly".

Facebook obviously would rather not wade into such petty blame games around data breach collateral, but it's worth pointing out that this particular incident involves the personal identifying information of half a billion people in over a hundred countries around the globe. Alon Gal, the Chief Technology Officer of the information security firm Hudson Rock, and the person who initially alerted the world to the stolen data, identified that 7,320,478 Australian accounts were available in the 70GB data trove. That's 28 percent of all Australians and over 65 percent of the total number of local Facebook accounts.

The breach is known to include phone numbers, Facebook IDs, full names, dates of birth, gender, locations, bios, marital status, employer and in some cases email addresses.



JOEL BURGESS

When not reviewing PCs for APC and writing our funny pages, Joel likes to ponder tech and how it's used.

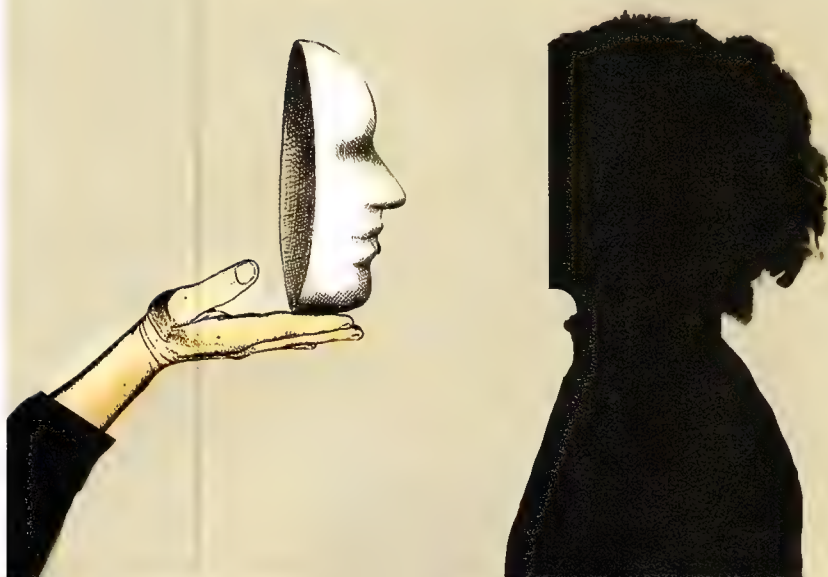
If you're wondering if your account was on the list then you can head over to haveibeenpwned.com and type in your mobile number with the +61 international code, but when two in three Facebook users were known to have been breached, it's safe to assume your phone number and identifying information will now be available to online scammers until you change it.

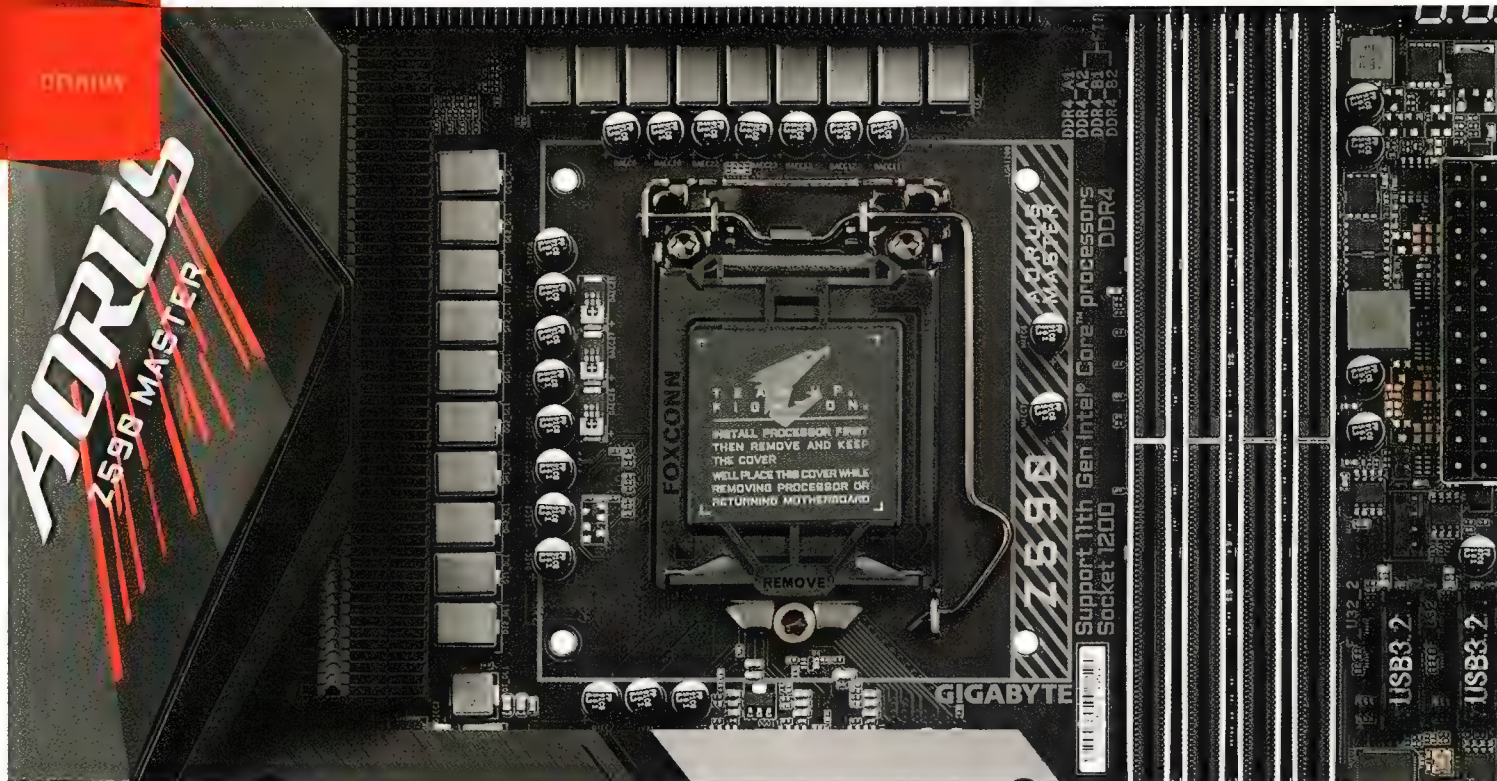
If you're like us and have suffered a major uptick in the number of fake ATO legal action calls you've received in the last month, then you can thank Mark Zuckerberg for that... and based on the company's nonchalant response, you should basically just expect that Facebook is going to continue to lose your data on a regular basis from now on.

There's no doubt that there has been a major uptick in the frequency and size of data breaches in the last few years, but generally they've been email, username and password details for accounts. For anyone using generic passwords across multiple accounts this is a danger, but for anyone that takes care to manage their passwords, the remedy was easily cauterised by resetting a single password. The Facebook breach is different, since it's harder to change things like your phone number, name and date of birth.

Apple's Tim Cook has been criticising Facebook for its data practices for years now, directly suggesting to Zuckerberg in 2019 that Facebook delete any data collected outside of its core apps. Apple has even updated its latest iOS version to allow users to opt out of off app tracking by services like Facebook... which, in light of how much Facebook seems to care about keeping your data safe, is starting to seem like a pretty major perk for any iPhone users. ■

"Facebook obviously would rather not wade into such petty blame games around data breach collateral, but it's worth pointing out that this particular incident involves the personal identifying information of half a billion people in over a hundred countries around the globe."





TWO BITS

Intel B560 boards are actually good!

But not all of them.

In this issue we cover four 11th Generation-supporting Z590 motherboards. They bring a lot to the table, but still, most people balk at the idea of dropping half a grand on a motherboard, especially if you're looking for a new hyper-cost-inflated GPU as well. Right now, you're not likely to get much change from \$2,000 even for a fairly basic gaming PC. There's an affordable motherboard alternative though, and this time around, it's one worth considering. Enter the B560 chipset.

Intel's B460 motherboards, and the B series chipsets before that were... average. A significant drawback was the lack of memory overclocking, with a maximum of DDR4-2933 on i7 and i9 CPUs. B460 with a high-end CPU wasn't all that common, so really, you were looking at a maximum of DDR4-2666 with a common pairing. I wasn't concerned about not being able to run overclocked DDR4-4500, but the ability to run 2020-class

DDR4 in the 3200-3600MHz range was a poor arbitrary limitation. That's all changed with B560. Now you can run faster memory, which means you're not giving away performance, and a decent set of DDR4-3200 costs basically nothing more than the slower speed stuff anyway.

B560 features several other improvements, depending on the particular board of course. You get USB 3.2 Gen 2x2 support (the USB naming drives me insane) plus USB 3.2 Gen 2 support and Wi-Fi 6. Then there's PCIe 4.0 support and perhaps most importantly of all, stronger VRM designs.

B560 boards need to be designed for a worst-case scenario. That means it needs to support an i9-11900K with its 250w PL2 power limit. That's not an easy load for a motherboard. The cheapest B560's don't come with any VRM cooling, making such a combination insane, but boards in the \$250 range do have a semi decent or better VRM and some form of cooling. This



CHRIS SZEWCZYK

A life-long PC tech enthusiast,

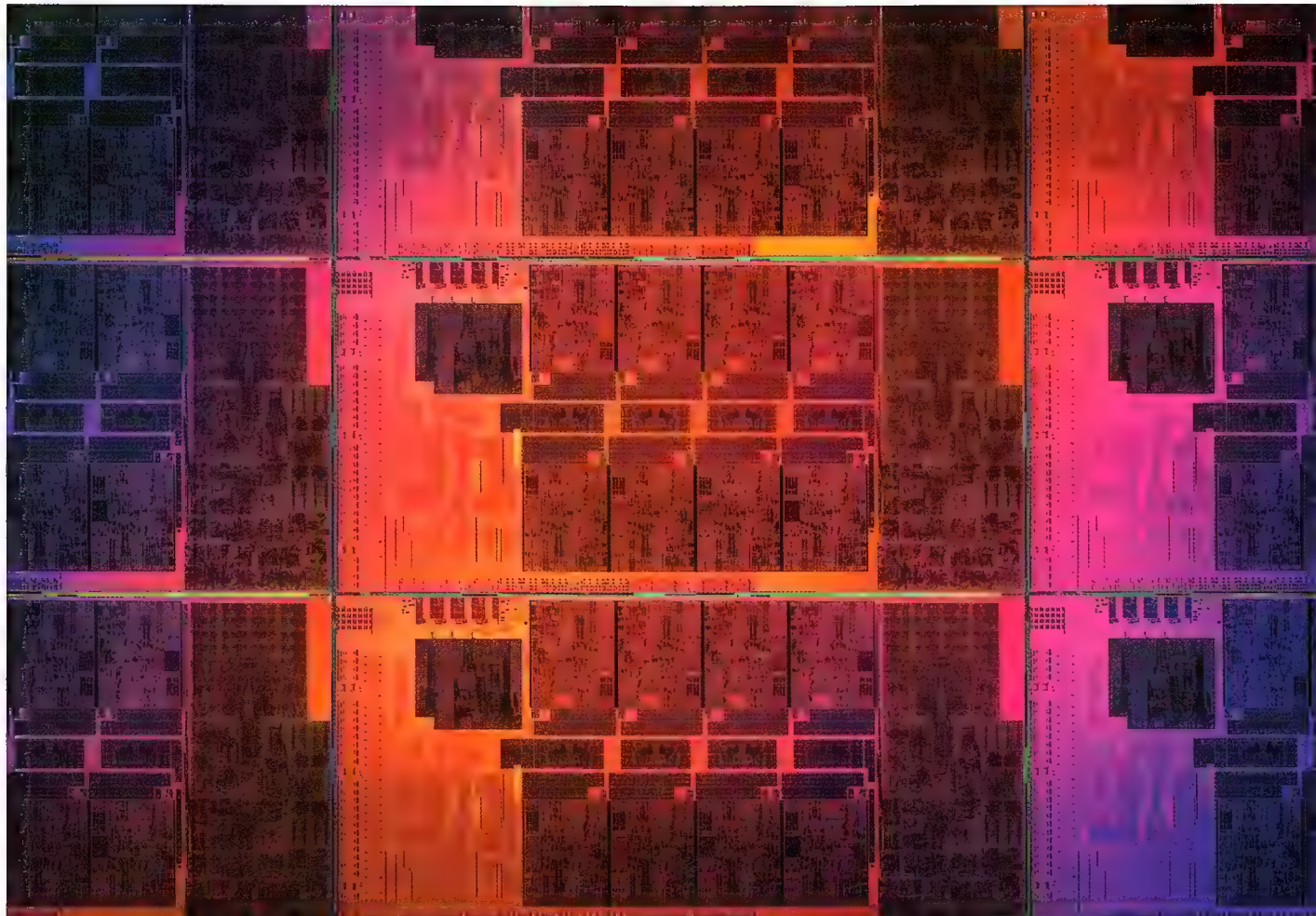
Chris has worked across the industry in many areas as a product and technology expert.

means you can theoretically run an 11900K, an RTX 3090, a 7,000MB/s SSD and 128GB of fast memory on a B560 board. Such a combination, although unlikely, is actually perfectly feasible on one of the premium B560 boards at around the \$300 mark. That kind of combo would embarrass most Z590 setups.

B560 motherboards support 10th generation CPUs, though you won't get PCIe 4.0 support. With the discounts on offer, many 10th generation CPUs provide excellent bang for buck. A gamer on a budget could do far worse than grab a 10700F and a decent PCIe 3.0 SSD. That's a good, smart gaming combo that will last you for several years and it will happily accept a high end GPU if/when supply returns to normal. Don't forget you can also make use of the improved 11th Gen Xe integrated graphics, in which case you wouldn't need a GPU at all.

The bottom line is that B560 boards, for the most part, have taken a serious step forward, much like AMD's B550 did. The vendors want you to buy Z590, and they're good boards, but don't overlook B560. Pair one with the right components and you'll give away nothing in terms of performance and you'll save a few bucks at the same time. ■

"Right now, you're not likely to get much change from \$2,000 even for a fairly basic gaming PC. There's an affordable motherboard alternative though, and this time around, it's one worth considering. Enter the B560 chipset."



TECH TALK

Rocket Lake's launch

The good and bad that comes with this new generation.

Intel launched its Broadwell desktop processors in 2015. Those were the very first 14nm chips to hit the market, and even after delays, Intel was basically two years ahead of the competition. So, it seems practically inconceivable that, nearly six years later, we're now looking forward to the seventh Intel CPU generation to use a variant of 14nm lithography.

Intel stumbled, badly, on the transition to 10nm. Yes, we know 10nm Ice Lake processors have been shipping since 2019, and SuperFIN (10nm+) Tiger Lake CPUs launched last year. But both were confined to mobile solutions, suggesting Intel was still not ready to make bigger 10nm chips. Server-class Ice Lake-LP 10nm Xeon CPUs and desktop and mobile Alder Lake parts will change that later this year. In the interim, we have Rocket Lake. It feels a lot like a repeat of what we saw with Broadwell desktop chips: Too little, too late.

Rocket Lake packs new Cypress Cove CPU cores, an architectural back-porting of Ice Lake's Sunny Cove cores to the 14nm process.

Sunny Cove originally used 10nm lithography, and back-porting means Intel had to rework things. There are architectural differences, and a trimming down in CPU core counts compared to existing desktop chips. Comet Lake offers 10-core/20-thread solutions at the top of the stack; Rocket Lake drops to eight-core/16-thread models. It looks very weak compared to AMD's 12- and 16-core offerings.

The Cypress Cove cores bring upgraded AVX512 support, but that's problematic as it's not widely used. With the right workloads, it can provide a significant boost to performance, but AVX can also cause a massive jump in power use.

Rocket Lake is Intel's first desktop chip to support PCIe Gen4, too, doubling the bandwidth between the CPU and graphics card. The CPU comes with 20 Gen4 lanes, including four dedicated for the first M.2 slot and 16 for the first PCIe slot, similar to AMD's Ryzen platforms as well as Comet Lake. Intel also doubled the width of the DMI 3.0 connection between the CPU and



JARRED WALTON

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

the PCH chipset, from x4 to x8. That will improve throughput to storage devices and peripherals, but it's only on "select" 500-series motherboards, but not B560 or H510. 400-series boards are also limited to x4 DMI.

Finally, Rocket Lake includes Intel's 12th Gen Xe Graphics. All of the Skylake-derived CPUs of the past six years have used some variant of Gen9/9.5 graphics, while Ice Lake laptops included 11th Gen. Tiger Lake moved to 12th Gen Xe Graphics, with up to 96 EUs (Execution Units), and Rocket Lake also has Xe Graphics, but only up to 32 EUs.

Alder Lake is due this year, though, and its Enhanced SuperFIN 10nm process and Golden Cove cores should beat Rocket Lake. With the 11900K using up to 250W peak power, waiting for Alder Lake seems sensible. The saving grace for Intel is that its 14nm node is mature, with good yields. While AMD looks to increase output of Zen 3 chips, and everyone competes for wafer starts at TSMC, Intel should have plenty of chips to go around. ■



HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND



Two screws secure the Lightning port, making this high-wear part easy to replace if it breaks.



Backbone One

A more interesting than usual game controller.

The Backbone One sneaks into the mobile gaming market with a handful of interesting features, including a pass-through Lightning port, headphone jack, and some dedicated controls, such as gameplay recording and instant muting. But is this compact iPhone controller as repairable as it is tactile? Let's see!

Major tech specs

- D-pad and thumbstick on the left
- A-B-X-Y buttons and thumbstick on the right
- Shoulder and trigger buttons on each side
- Lightning port for pass-through charging and accessories
- 3.5mm headphone jack
- A soft-touch Smart Case and a Lightning-to-USB-C cable

Key findings

- This Joy-Con-esque controller may look like any other mobile gamepad – but it packs a few surprises. A couple of interesting omissions, though, are Bluetooth and an internal battery. The Backbone One connects to and draws power from your iPhone.
- We're off to a fast start thanks to Phillips screws on the right grip. Beneath the plastic shell, some colorful cables – and our first look at the internals. We free the interconnect cable from its ZIF connector claw and unplug the

two Lightning connector cables from the motherboard. A few more Phillips screws later, we can extract the shoulder button, trigger, and our first PCB.

- Let's see what this board brings to the game: joystick (soldered to the board – not a great start), six clickable contacts (tactile dome) for the A-B-X-Y buttons, orange Backbone App button, and option button. It also has Skyworks SKY52101-11 IoT SoC, Avnera AV3425C single chip analog SoC for smart Lightning headsets, and soldered-on bumper button, Hall-effect sensor for the trigger button, and Lightning port to pass through power to your phone or sound to your headset.
- Over on the left side we find an almost identical setup, but we're momentarily stumped trying to remove the trigger button. Turns out, it's secured by just one well-hidden screw. The left board offers another soldered joystick (like the Razer Kishi), four gold contacts for the direction pad and four holes to keep its silicone cover in place, and two clickable silver contacts (tactile dome) for the screenshot/record and option buttons. You can also find a soldered 3.5 mm headphone jack, bumper button, and Hall

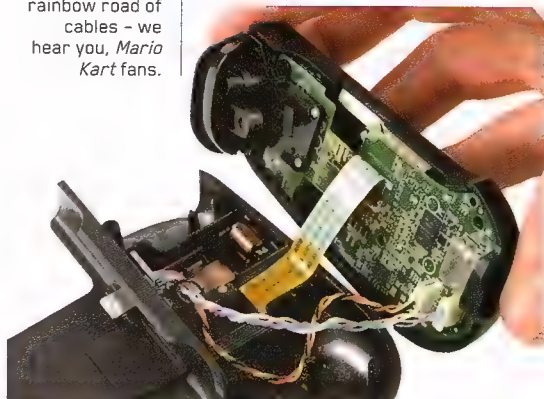


The use of Phillips screws rather than glue to hold it together makes the Backbone One easier to fix.



The left side has an almost identical setup to the right side – all the way down to the Phillips screws and ZIF connector.

Cracking open the casing reveals a rainbow road of cables – we hear you, *Mario Kart* fans.



sensor for the trigger button.

- The sliding clamp mechanism uses a pair of flat spiral springs that unroll when you pull the handles apart. This provides more consistent compression and a tighter grip than the Razer Kishi, which uses helical extension springs to embrace your phone.
- Two screws secure the Lightning port. With the right tools, some case-modding, and rewiring, you might even be able to swap it out for a wider USB-C port to make it Android-compatible. The interconnect cable wiggles in the casing but can't be removed without causing irreparable damage. We free the springs with our Minnow Precision Bit Set and save the game before the final boss. We have beaten the Backbone One.
- Repairability Score: 5 out of 10 (10 is easiest to repair). Disassembly is straightforward with components held in place with screws. The Lightning connector can be easily replaced by removing the cover and two screws. No adhesive is used, but some screws are difficult to reach. Shoulder buttons are soldered to their boards, requiring micro-soldering skills for replacement. Both joysticks are soldered to their boards, as is the pass-through Lightning port. ■



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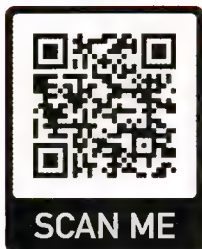
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GADGETS

TECHY TOYS THAT MAY OR MAY NOT INSPIRE JOY

\$57 | 8bitdo.com/n30pro-2

8BitDo N30 Pro 2

8-bit style with USB-C charging.

Bluetooth controllers can be annoyingly limited when it comes to compatibility, but the new N30 Pro 2 manages to cover all bases by connecting to Windows, Android, MacOS, Steam, Switch and Raspberry Pi. As the second generation of 8BitDo's NES-inspired controllers the new offering brings new motion controls, vibration and turbo keys. The controller now connects and charges via USB-C and you can purchase an Xtander grip to mount your smartphone to it. With clickable joysticks, a D-pad, Start and Select buttons and the usual four right thumb button array you can play pretty much anything with these controllers.

\$1,699 | Store.dji.com/au

DJI Air 2

An automated drone that makes professional level cinematography easy.

DJI is pretty much the last man standing in consumer drones, and there's a good reason for that. The Air 2 S is one of the most compact foldable drones we've seen at 600g, but despite this super portable design it still manages to pack a 20MP camera with a 1-inch sensor. This means you'll get up to 5.4K 30fps resolutions and impressive HDR and low light images from the drone. Add to this four dimensional obstacle avoidance tech and a new suite of automated, object-tracked cinematic shot movements and anyone can shoot dynamic footage without having to be a flight expert.





\$199.95 | fitbit.com

Fitbit Luxe

Fitbit wants to spoil you with its next fitness tracker.

Fitbit's latest update to its line of fitness trackers is keen on adding a bit of luxury to this pragmatic wearable. In addition to adding some premium looking finishes to the new white, graphite, pink and gold wristband colourings, the Lux also includes a slim AMOLED colour display and an active zone minute counter that was only available on the smartwatch range previously. While the new device does retain the swim tracking water resistance and you'll get the five day battery life of other trackers it does unfortunately miss out on Fitbit Payments, which will be a big loss for anyone hoping for that extra payment convenience.

\$TBC | asus.com

Asus ZenBeam Latte

Get your movie fix while on the move.

With all the regional travel going on at the moment chances are you're doing some camping or Air BnBing, and what better way to fill your downtime than with good TV or a movie. The Asus ZenBeam Latte L1 portable LED projector and speaker package that you can take on the road with you. With a 720p display size of up to 120-inches and a three hour battery life everyone can watch the big screen from wherever you are. The 300 lumen brightness means it's only really good at night and the streaming options aren't as robust as we'd like but you can connect whatever you want via HDMI.



\$NA | youtu.be/7a3JiGTE9sc

Ferrofluid speaker

The magnetic fluid in this Bluetooth speaker dances to music.

Ferrofluid is a metallic fluid that was developed by NASA in the 60s to move jet fuel to a nozzle in zero gravity by exposing it to a magnetic field. The liquid has taken on a new life recently by using music to animate the fluid into artistic shapes when placed near speakes (which use magnetic fields to resonate sound). While these displays have generally been limited to messy workshops where the fluid could be poured directly onto exposed speakers, one Hackday creator built a Bluetooth speaker with a Ferrofluid bubble in the centre that dances to whatever music is playing.



\$TBC | urbanista.com/au/losangeles

Urbanista Los Angeles

Solar-powered headphones for endless audio playback.

Solar panels are pretty good these days, but we didn't think they were quite ready to power portable technology for endless wireless playback. Swedish lifestyle brand Urbanista seems to think it is, releasing a range of solar powered ANC headphones called Los Angeles that have 'infinite playtime'. Considering parts of the country don't actually see the sun in January, we're a little surprised that a Swedish company is leading the solar powered headphone revolution, but it's a pretty neat invention if they can pull it off. ■



\$899 | www.amd.com

AMD Radeon RX 6700 XT

A card we need, at a price we don't.

Here we go again. There are a lot of very nice gaming cards on the market right now*. Note the asterisk. The RX 6700 XT is ostensibly a mid-range card but with the GPU market and the wider semiconductor market in a state of shock, normally affordable cards like this are selling at flagship price levels, and even then, availability is scarce. Let's hope that supply and demand will reach a happier state of equilibrium in the coming months and we can stop prefacing every GPU article with the same sad lament. Rank and file gamers that have no interest in paying \$1,000+ for a GPU are crying out for new and affordable card. Let's hope the 6700 XT can take its place as a compelling mid-range challenger

The 6700XT's heart

The RX 6700 XT features the Navi 22 GPU, which is the second RDNA2-based GPU to be

released. This version of the Navi 22 GPU contains 17.2 billion transistors in its 335 mm² die area. The 6700 XT packs in 2,560 stream processors and 40 ray accelerators. We'll likely see a cut down version used for a 6700 or 6600 XT at some point in the future. The 192-bit bus of the 6700 XT can be considered narrow but the 12GB of 16Gbps GDDR6 memory still manages to provide 384GB/s of bandwidth. The 6700 XT GPU includes 96MB of what AMD calls Infinity Cache which supposedly offsets the need for a very wide bus.

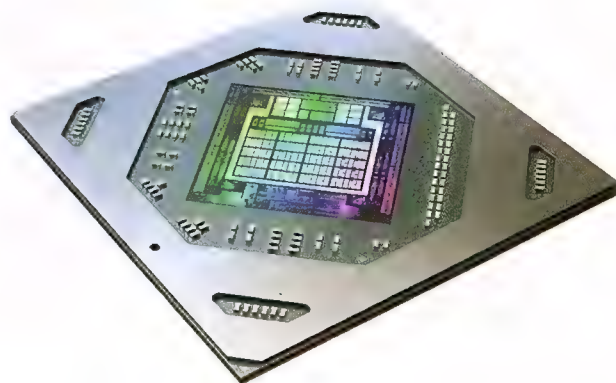
With help from the now mature TSMC 7nm process, AMD has made great leaps forward when it comes to the clock speeds of its GPUs. The 6700 XT features a boost clock of 2581MHz. The fact that we're seeing these kinds of clocks without resorting to runaway power consumption is admirable. Though at 230W, the TDP is about the maximum we'd

SPECS

AMD Radeon RX 6700 XT; 2,560 Shader Cores; 2,321 MHz Base Clock, 2,581MHz Boost Clock; 12GB 16Gbps GDDR6 memory, 384GB/s Memory Bandwidth; 3x Display Port 1.4a, 1x HDMI 2.1; 1x 6-pin + 1x 8-pin Power Connector, 230W TDP.

want to see on a mid-range card.

We were really impressed by the build quality and cooling capabilities of the reference 6800 series cards. The 6700 XT is another well-built reference design. The performance of the cooler isn't bad but as expected it can't match the monster triple slot 6800 and 3080-class coolers that many partner cards make use of. Still, it's light years ahead of the noisy and inefficient blower of the 5700 XT. The card features an attractive design with a solid metal backplate, dual fans and a nice looking red LED Radeon branding along the front. There's also fan-stop functionality when the card is idling. Note that the cooler doesn't protrude above the



"Let's hope that supply and demand will reach a happier state of equilibrium in the coming months and we can stop prefacing every GPU article with the same sad lament."

"We're going to have to get used to AMD lagging a little in ray tracing performance this generation and we're yet to see AMD's equivalent DLSS implementation."



height of the I/O bracket, which will appeal to SFF users. Could AMD have allowed some air to pass out to the rear of the card? It would seem to be a conscious decision to block it off completely.

The card features a now standard three v1.4 DisplayPorts and a single HDMI 2.1 port. The PCB contains a nine-phase VRM with a further two for the memory. Single 8-pin and 6-pin power connectors means there's more than enough power on tap.

Performance

Now we come to the crux of it all. How does it perform? AMD hyped the 6700 XT as a 3070 competitor but in our testing, we found it to be competitive with the 3060 Ti. It's well suited to high refresh rate 1080p gaming and it will run any game at 1440p. We're going to have to get used to AMD lagging a little in ray tracing performance this generation and we're yet to see AMD's equivalent DLSS implementation. If RT and DLSS aren't important to you at this point in time then the 6700 XT is very solid. There's not a huge amount of OC headroom on tap, though as always, your mileage may vary. Our card was able to maintain average 2,690 MHz though we think there would be more in it if we could increase the power limits and memory frequency further than their frustratingly low limits.

Conclusion

The 6700 XT offers a good level of performance and its 12GB of memory should see it appeal to many mainstream gamers who are looking to step up from a card that's a few years old. It trades blows with the 8GB 3060 Ti but it falls behind when ray tracing is factored in. We'll have to wait and see if that extra memory makes a difference in future AAA titles, but for now, at this level of performance, it doesn't. It's the price that hurts it, and every other card for that matter. A card that's too expensive today like the RX 6700 XT might become a midrange champion when supply returns to normal. It's a tough time to upgrade. CHRIS SZEWCZYK

The RX 6700 XT is a capable 1440p card, but we can't recommend it until it comes down from its inflated price level.

★★★★☆

A vertical advertisement for TechRadar. The background is a dark blue gradient. At the top, there are several circular icons containing various tech-related items: a game controller, a drone, a camera, a smartwatch, a smartphone, a pair of headphones, a speaker, and a speedometer showing 72. In the center, there is a large, stylized monitor displaying the 'techradar' logo in white and black text. At the bottom, the text 'The source for tech buying advice' is written in a large, white, sans-serif font. At the very bottom, the website 'techradar.com' is displayed in a smaller, white, sans-serif font.

AMD Radeon RX 6700 XT benchmarks

On test

	Metro: Exodus				F1 2020			
	1920x1080 Ultra Preset		2560x1440 Ultra Preset		1920x1080 Ultra High Preset		2560x1440 Ultra High Preset	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070	52.8	98.4	44.1	78.3	164	204	133	157
Nvidia GeForce RTX 3060 Ti	44.3	86.6	39.1	69.6	148	181	117	140
Nvidia GeForce RTX 3060	35.4	64.3	30.1	51.1	112	138	86	104
AMD Radeon RX 6800	57.7	102.8	50	84.4	163	219	135	174
AMD Radeon RX 6700 XT	49.9	87.5	42.4	69.7	140	192	112	145
AMD Radeon RX 5700 XT	38.7	70.3	32.3	55.5	121	156	101	123

	Middle Earth: Shadow of War				Total War: Warhammer II			
	1920x1080 Ultra Preset		2560x1440 Ultra Preset		1920x1080 Ultra Preset		2560x1440 Ultra Preset	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070	55	156	47	114		114.4		83.7
Nvidia GeForce RTX 3060 Ti	51	141	45	103		105.8		78.2
Nvidia GeForce RTX 3060	40	108	40	77		84.6		58.3
AMD Radeon RX 6800	43	176	41	130		120.8		91
AMD Radeon RX 6700 XT	52	151	46	104		104.9		75.1
AMD Radeon RX 5700 XT	40	112	38	74		82.7		55.9

	Ghost Recon: Breakpoint				Civilization VI			
	1920x1080 Ultimate Preset		2560x1440 Ultimate Preset		1920x1080 Max Settings		2560x1440 Max Settings	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070	60	103	60	83	147.8	198.3	124.7	162.4
Nvidia GeForce RTX 3060 Ti	60	97	60	77	128.7	174.7	108.5	142.7
Nvidia GeForce RTX 3060	60	78	49	61	90.2	127.3	76.4	103.1
AMD Radeon RX 6800	60	111	60	93	159.5	206.6	136.2	172.6
AMD Radeon RX 6700 XT	60	106	60	81	139.6	183.8	115.3	148.6
AMD Radeon RX 5700 XT	59	91	54	66	96.1	139.7	86.6	131.9

	Watch Dogs: Legion (RT & DLSS Off)		Watch Dogs: Legion (RT Ultra & DLSS Off)		Far Cry New Dawn			
	1920x1080 Ultra Preset	2560x1440 Ultra Preset	1920x1080 Ultra Preset	2560x1440 Ultra Preset	1920x1080 Ultra Preset		2560x1440 Ultra Preset	
	Avg	Avg	Avg	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070	86	67	54	37	89	131	89	119
Nvidia GeForce RTX 3060 Ti	77	60	49	33	83	129	89	113
Nvidia GeForce RTX 3060	60	46	38	27	89	115	74	91
AMD Radeon RX 6800	95	72	44	31	96	139	97	134
AMD Radeon RX 6700 XT	87	65	35	24	87	126	86	114
AMD Radeon RX 5700 XT	67	48	N/A	N/A	73	119	81	103

	Temperatures (°C)		3DMark			
	Idle	Load	Time Spy Extreme	Fire Strike Extreme	Port Royal	RT Feature test
Nvidia GeForce RTX 3070	32	73	6,459	16,094	8,077	32.67
Nvidia GeForce RTX 3060 Ti	39	66	5,895	14,220	7,035	27.18
Nvidia GeForce RTX 3060	38	63	4,209	9,998	4,946	18.98
Nvidia GeForce RTX 3060	37	67	6,907	20,274	7,603	22.05
AMD Radeon RX 6800	40	79	5,553	16,441	5,824	13.21
AMD Radeon RX 6700 XT	37	82	4,613	12,207	N/A	N/A
AMD Radeon RX 5700 XT						



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\$1,799 | [Lenovo.com/au](https://lenovo.com/au)

Lenovo Yoga 7i Carbon

Did Lenovo just put the aluminium chassis in its rear-view mirror with the new Yoga 7i Carbon?

The Yoga range from Lenovo has been one of the most consistently standout convertible ultrabooks over the last few years, and while the new Yoga Slim 7i Carbon borrows its namesake form this long lineage, it's not actually a convertible... or even a touchscreen laptop. The Yoga 7i Carbon is a 13.3-inch Intel Evo clamshell that features a carbon fibre chassis to keep the total weight to just 966g, around 25 percent lighter than your average 13-inch Evo. Despite this the chassis feels sturdy and because the material is around 40 times less conductive than aluminium, you won't feel the computer heat on the keyboard surround. Traditionally carbon fibre-clad laptops needed additional cooling architecture, but Intel's 11th generation G7 laptop processors are efficient enough to mean this device actually keeps relatively cool, hitting a maximum of 91 degrees throughout our tests.

The Yoga 7i Slim comes in two

variations locally. Both include a 13.3-inch QHD IPS display, 16GB of RAM and a 512GB M.2 SSD with the main difference being processor and OS spec. The Intel Core i5-1135G7 model gets Windows 10 Home and comes with an RRP of \$2,249 while the Intel Core i7-1165G7 variant is privy to Windows 10 Pro and an RRP of \$2,699. Fortunately we've seen both these models available for considerably less, with some retailers offering the i7 model with W10 Home for just \$1,799 – a really competitive price point for a premium ultrabook.

The 16:10 screen features a higher than average 2560x1600 QHD resolution and has been certified to meet the Dolby Vision standard for HDR streaming. The display is only capable of reproducing the sRGB gamut though, so you won't have enough colour accuracy to do any professional work, but media at least looks good on the screen. At 300 nits it's not the brightest display we've

looked at, but it is above average against contemporaries.

Performance was where you would expect it to be, landing around the same scores as other devices with similar setups. This means there'll be plenty of power overhead for general work tasks, light photo editing and you'll even get playable frame rates on games at Low 1080p settings.

The keyboard was nice to type on for an ultra-thin laptop and the trackpad wasn't annoying. You'll have to be fully converted to USB Type-C peripherals since that's the only interface option on the three ports other than a 3.5mm audio jack. It's not an unreasonable layout these days and the device does come with an HD webcam and 2W Dolby Atmos speakers so you'll be fine for any remote conferencing or webchats.

It does miss out on a fingerprint reader, but with Windows Hello facial recognition signing you in the second you open the lid, you don't really need it.

The 50Wh battery was slightly lower than the average amongst 13-inch ultrabooks in 2021, but it still managed to last 10 hours and 49 minutes in PCMark 10 Home Office battery benchmarks and six hours and 45 minutes in 1080p movie playback. This should get you through the average day without needing to juice up.

JOEL BURGESS

A neat 2-in-1 with a lightweight stylus that is great for basic office tasks.

★★★★★

	Lenovo Yoga Slim i7 Carbon	LG Gram 17
Best result		
On test		
PCMark 10 - Overall (score)	4,514	4,692
Cinebench R23 - CPU (multi-threaded)	4,845	3,476
Geekbench 5 - Multi-core (score)	5,327	4,568
3DMark Fire Strike (score)	4,265	3,955
Battery life - 1080p video playback (h:min)	6h44min	14h47min
Peak CPU temperature (°C)	91	95
CrystalDiskMark Read (MB/s)	3,564	3,443
CrystalDiskMark Write (MB/s)	2,344	2,120



\$3,009 | lg.com/au

LG Gram 17

LG's lightweight professional laptop finally arrives Down Under, but is it good enough to take home a Grammy?

As the name may suggest, the Gram is an extremely lightweight laptop from LG, even among some of today's most portable Ultrabooks. It's been a long time since LG has had a laptop in the local market, but it's not shying away from the competition, offering a bigger and better screen and one of the longest battery lives across the whole range of devices.

The LG Gram laptop range is available in three sizes, 14-, 16- and 17-inches, which have RRP's that range from \$1,799 to \$3,009. The smaller devices all get Intel Core i5-1135G7 processors and 72Wh batteries, with the entry level models seeing 8GB of RAM and a 256GB M.2 SSD. You can opt for 512GB of onboard storage on the 14-inch devices for an extra couple of hundred dollars, but if you want more powerful components you'll have to go for a larger device.

The 16-inch models come with a

generous 80Wh battery and can be configured with 16GB of RAM and an Intel Core i7-1165G7 for a total of \$2,809 while the 17-inch Gram gets all these top line specs and a slightly bigger screen for \$3,009.

We haven't really tested enough larger units to really assess how well the 17- and 16-inch models are priced, but the 14-incher seems to line up with some of the better value 11th Gen ultrabooks we've tested... even if it is limited to a less powerful Core i5 CPU and 8GB RAM configuration.

The 17-inch LG Gram weighs in at 1.35kg, equivalent to most of today's 13-inch ultrabooks. It's an impressive feat for something that accommodates a 28 percent bigger screen and generous battery. The 16-inch and 14-inch devices aren't carrying much excess weight either at 1.19kg and 999g, respectively.

In benchmarking the Gram 17 performed as you'd expect, within

SPECS

Windows 10 Home
64-bit; 17-inch
DCI-P3 IPS display
at 2560x1600
pixel resolution;
Intel Core
i7-1165G7 CPU;
16GB RAM; Intel
Iris Xe Graphics;
512GB M.2 SSD;
80Wh battery
(14h47min 1080p
movie playback
lifespan); 38 x 26
x 1.8cm; 1.35kg.

about 15 percent either side of our Evo average for all CPU tests, so it's got plenty under the hood for everything but demanding creative work. This device did sadly underperform in gaming benchmarks with scores up to 35 percent behind 11th Generation Intel Evo averages. It's possible these are just early driver kinks, but if lightweight gaming is a priority you'll want to look elsewhere.

The screen, whatever size you opt for, offers a great balance of premium features that don't drive cost up too high. The screen is a slightly taller 16:10 proportion, which is better for web pages and general office use but also features a WQXGA 2560x1600 pixel array for a slightly more than FullHD clarity. It's not the brightest display we've seen but it does come with a 99 percent DCI-P3 colour gamut which is enough to do colour grading touch ups for media on the go.

The extra wide keyboard takes a bit of getting used to since the ratio of vertical to horizontal space is novel and it sits an awkwardly long way back from the front edge, but it works well enough over long periods to not be an issue.

Battery life was great in battery saver mode lasting well over a day in general work cases and 14 hours and 47 minutes in 1080p movie playback. JOEL BURGESS

A lightweight premium ultrabook with some HDR screen perks and a big battery.

★★★★★

Best result
On test

	LG Gram 17	ADATA XPG XENIA Xe
PCMark 10 - Overall (score)	4,692	4,750
Cinebench R23 - CPU (multi-threaded)	3,476	3,301
Geekbench 5 - Multi-core (score)	4,568	4,156
3DMark Fire Strike (score)	3,955	5,158
Battery life - 1080p video playback (h:min)	14h47min	12h59min
Peak CPU temperature (°C)	95	98
CrystalDiskMark Read (MB/s)	3,443	4,979
CrystalDiskMark Write (MB/s)	2,120	4,245



\$499 | au.msi.com

MSI Modern MD271QP

A modern monitor that's designed to blend into a home or office without offending your eyes

In a world of increasingly commoditised technology, computer monitors represent an area where you'll want to avoid buying the wrong thing. Prices vary wildly, many specialise at displaying certain types of media in a way that's detrimental to other types of media, and while superlative do-it-all monitors do exist, they can easily cost ten times more than what you actually need.

Against this backdrop, MSI has launched the 27-inch Modern MD271QP which is part of its Business/Learning range. It's designed primarily for productivity and eye comfort with an additional eye on not looking ugly in the home or office. So, is it any good?

It looks smart (as monitors go) with clean lines, a thin bezel and a reasonably small-but-sturdy stand. There's a generous degree of height (110mm), tilt (-5° to 20°) and swivel (-30° to 30°) adjustability. It also fully rotates into portrait mode. The IPS panel ensures that changing viewing angles don't impact on contrast or colours. Though the bezel is thin, there's a black deadzone at the top and sides of the screen which would impact

upon tiling multiple monitors.

The resolution is a crisp 2,560 x 1,440 which means that Windows Desktop, office documents and small fonts are displayed sharply and accurately.

MSI has gone to great lengths to ensure the MD271QP is kind to your eyes. The matte, anti-glare coating works well, but the main features come via the electronics and OSD controls. The menu is operated by buttons at the base and it soon became quick to navigate around (you can also use MSI's Display Kit Windows application). While it's difficult to perceive the flicker-free benefits from the slightly-higher-than-usual 75Hz refresh rate, you'll certainly notice the aggressive blue light filter which warms the screen up considerably. There are many pre-sets including colour temperature, media mode (Standard, Movie, FPS, RTS and Low Blue Light), Eco mode, dynamic contrast and gamma and you can tinker with everything manually. Ultimately, its quick to make significant changes to match your personal preferences.

Colours appear muted and dull in many modes, but matters do improve if you turn off Eco mode and choose gaming or cinema

SPECS
27-inch, matte,
2,560 x 1,440,
flat-screen, 75Hz
LCD with IPS
panel, 250 nit
brightness,
1000:1 contrast,
DisplayPort 1.2,
HDMI 1.4, USB-C
(HDMI 2.0 signal),
3.5mm audio jack,
Tilt -5°/+20°,
Swivel -30°/+30°,
90° rotate, 11cm
height
adjustment, 614 x
402 x 200 mm,
5.8kg.

pre-sets. While it can't compete with glamorous, HDR-enriched rivals, video can still look colourful and vibrant. We were also very impressed with contrast performance: while bright objects don't gleam, dark backgrounds approach true black and there are minimal bright halo effects bleeding from bright objects.

Gameplay smoothness is average: if you're used to a fast refresh rates for frantic FPS battles, the 75Hz maximum will feel limiting.

Connectivity is generally good for such a monitor, while there's no USB hub, it's good to see a modern USB-C port joining the HDMI and DisplayPort sockets. There are also built-in speakers but don't expect much from them: while there's a modicum of volume they're generally tinny, lack any punch.

Ultimately, it's a good middle-of-the-road monitor that will suit most office and school workers who dabble in multimedia. At \$499 it's decent value too.

NICK ROSS

It's more about eye comfort than eye-popping performance which makes it a great choice for general home and office use.

★★★★☆



\$345 | thermaltake.com.au

Thermaltake Toughpower PF1 ARGB 850W PSU

A tough power supply from Thermaltake that can handle harsh conditions.

The Thermaltake Toughpower PF1 with 850-watt max power is a decent PSU that packs many good features. With 850W capacity, this PSU can handle a power-hungry CPU and GPU combo, for example, an Intel i9-10900K or AMD Ryzen 9 5950x and an Nvidia RTX 3080 or AMD RX 6800XT. It features an RGB-everywhere approach, with 18 configurable LEDs, an RGB fan and ARGB side panels that illuminate the product branding, and is compatible with Asus, Gigabyte, MSI and Asrock lighting systems.

On the 80 PLUS scale, the PF1 850 is classified as Platinum, while in Cybenetics, it earns the ETA-A and LAMBDA-A- efficiency and noise ratings. All cables are modular, and the cooling fan uses a hydraulic bearing with long life under normal operating temperatures. Finally, the PSU features semi-passive operation, meaning that its cooling fan doesn't spin at low loads to keep

the noise output low. You can toggle this mode off if you want the fan to run constantly.

There are plenty of cables and connectors, including two EPS, six PCIe, twelve SATA and four 4-pin Molex. There is even an FDD adapter provided for those of you that might need one. Cable length is satisfactory, and it is nice to see an adequate distance between the peripheral connectors. Lastly, there are no in-cable caps, which make cable routing a tough task.

The design is clean, allowing for increased airflow, and the lack of proper heat sinks on the secondary side makes a huge impression. On the contrary, the heat sink on the primary side is quite large, always for this efficiency category's standards. Thermaltake used good electrolytic caps and an HDB fan. The FETs look to be of good quality, too.

The transient filter does a decent job of suppressing EMI emissions. The only problem is that it doesn't include an MOV, which protects

against voltage surges. Finally, there is an NTC thermistor-relay combo for lowering the inrush currents.

The 12V FETs are soldered on the top side of the PCB. Usually, these FETs are on the PCB's solder side, and some manufacturers also use the PSU's chassis to cool them down through thermal pads. The advantage of having them in this area is that the unit's fan can directly cool them. At normal operating temperatures, the fan speed profile is relaxed compared to high ambient. In no case did the PSU's fan noise exceed 40 dBA.

The competition is tough in this category, and this is a good PSU. The build quality is satisfactory, and the manufacturer used good parts, including Chemi-Con capacitors and a hydraulic bearing fan. It's an efficient unit that's nice and quiet under normal conditions. As expected, it's fully modular and sports a high number of connections.

ARIS MPITZIOPOULOS
AND BEN MANSILL

"With 850W capacity, this PSU can handle a power-hungry CPU and GPU combo, for example, an Intel i9-10900K or AMD Ryzen 9 5950x and an Nvidia RTX 3080 or AMD RX 6800XT."

The Thermaltake PF1 850 has decent overall performance, but it doesn't stand out in a category with stiff competition.

★★★★☆



"It doesn't just look good though, The Citadel punches above its weight in terms of performance."



\$2,399 | lcs.thermaltake.com.au

Thermaltake The Citadel

Thermaltake's Mini-ITX pre-built PC puts some serious firepower in a compact little tower.

Thermaltake's latest gaming tower, The Citadel, is a carefully considered system that balances performance against cost for a great overall configuration. The Citadel comes in just one model that features an AMD Ryzen 5 3600 CPU, an Nvidia RTX 3060 GPU and 16GB of RAM.

The AMD Ryzen 5 3600 might seem a little dated now that you can get the Ryzen 5 5600X, but that new processor is only around 15 percent better in general performance (seven percent in gaming) and costs 45 percent more than its predecessor. So including the Ryzen 5 3600 is actually a sensible choice for a price conscious gaming PC. This CPU is managed by Thermaltake's TH120 all-in-one RGB liquid cooler which kept the CPU under 70 degrees across all our benchmarks. That's plenty of overhead for anyone interested in overclocking the CPU a little further to push that peak

performance as high as it goes.

The GPU is an aftermarket card from Asus's TUF range that offers a triple fan array and manufacturer overclocking to ensure it's performing as well as it can. Thermaltake has included its own 3600MHz DDR4 ToughRAM sticks that include a nice RGB lighting system that you can sync to the cooler, GPU and motherboard lights for a custom synchronised PC glow.

There's not a heap of spare slots on the Asus ROG Strix B550-I Gaming AM4 Mini-ITX motherboard, but with gigabit Ethernet, Wi-Fi 6 AX200 wireless networking, a few USB ports (2xType-A, 2xType-C), and 3.5mm audio, mic and line-out ports there's enough interface options to connect all the essentials.

The most striking feature of this unit is that it is compact for a gaming PC. It's not a micro PC by any stretch, but put it up next to a full tower and it is less than half the

SPECS
Windows 10 Home
64-bit; Asus ROG Strix B550-I Gaming AM4 Mini-ITX; AMD Ryzen 5 3600; Asus TUF GeForce 3060 (OC 12GB) GPU; 16GB Thermaltake ToughRAM 3600MHz DDR4 (2x8GB); Thermaltake TH120 RGB AIO Liquid Cooler; 500GB M.2 SSD; 2TB HDD; Thermaltake Smart 600W 80+ Gold Power Supply; Thermaltake Tower 100 Mini Case - Black.

size. The Thermaltake Tower 100 Mini Case is taller and has a smaller footprint than many Mini-ITX cases which means the motherboard sits on the back with the GPU running vertically. This creates a nice looking arrangement that is super efficient on space. Cable management and hard drive bays are concealed behind a partition at the back while the Thermaltake Smart 600W 80+ Gold Power Supply is hidden neatly at the base. The interface ports are kept tidy behind a screen that feeds external input cables through neat holes at the back.

It doesn't just look good though, The Citadel punches above its weight in terms of performance. With two to three times the performance of today's top ultrabooks in media encoding benchmarks, this machine has more than enough raw power for demanding CPU heavy tasks. It also offers 90fps+ frame rates for demanding modern shooters on 1080p Ultra settings and can even manage playable frame rates using 4K Ultra or 1080p ray tracing scenarios on current titles.

The \$2,399 asking price is fair when you add up just how nice and compact this system is as a whole, but you can certainly find a better deal on a similar unit if you're happy to sacrifice on the form factor and overall sleek design of The Citadel. **JOEL BURGESS**

An awesome looking compact rig for 1440p gaming and light workstation needs.

★★★★★

■ Best result
■ On test

	Thermaltake The Citadel	Alienware Aurora R9
PCMark 10 - Overall (score)	6,526	5,715
Max CPU Temp (C)	70	67(94 OC)
HWBot x265 - 1080p (fps)	50.386	49.469
Cinebench R20 - multi-threaded CPU		3293
3DMark Time Spy (score)	8,608	9,155
Total War: Warhammer II - Ultra 1080p (fps Av.)	74.3	86
CrystalDiskMark Read (MB/s)	2,267	1,918
CrystalDiskMark Write (MB/s)	2,051	3,010



\$149 | www.mercusys.com/au

Mercusys MR70X Wi-Fi 6 router

The cheapest Wi-Fi 6 router we've seen. But what are the compromises?

With TP-Link moving from budget brand to one of the best on the market, it left a gap at the cheap end of the market. Say hello to its new junior brand, Mercusys.

Forget the new-fangled, fancy apps for setup, Mercusys embraces the old-school setup via web browser. The 'quick setup' is generally straightforward, but novices might be scared by some of the jargon. However, if you generally answer 'next' to all questions, while adding passwords when asked, you should end up connected. A 'Smartconnect' option allows you to bind the 2.4GHz and 5GHz bands together allowing the router's built-in smarts to choose the best connection for you. While we're not particularly confident in budget-grade, robot intelligence, we chose this for testing.

Browser-based settings are spread across four main pages. These include network map, internet status (with MAC clone), guest network options and an advanced tab where the rest of the settings can be found. The usual suspects are present but if you're not familiar with networking parlance and

acronyms you might get befuddled: for instance, it's been a while since we reserved a device's IP address by manually typing out its MAC address – seems Neolithic by modern standards.

Nonetheless, port forwarding, port triggering, UPnP and DMZ settings are all available. There are also settings for network operation schedules plus parental controls that manage bedtime and daily duration settings. Don't rely on the keyword blocking to protect your kids, though.

QoS settings involve prioritising internet traffic to specific devices. You can also whitelist and blacklist individual devices and update the router's firmware (manually).

In terms of hardware features, it offers Gigabit WAN plus three Gigabit LAN ports. There's also a WPS button for one-touch connectivity and WPA3 security is included.

The MR701 offers AX1800 speeds with a theoretical 1,201Mbps passing through the 5 GHz band and 574Mbps through the 2.4GHz band. We hoped that this facet, married with the four, large, spindly antennae, would provide impressive performance at range and so we ran our usual

SPECS
Speed: Dual-band
AX 1,800Mbps |
Connectivity: 3x
Gigabit Ethernet
LAN, 1x Gigabit
Ethernet WAN |
Features:
Parental controls,
QoS, Port
Forwarding.

tests in our three-storey Sydney townhouse. We placed the router on the ground floor, next to a Synology DS1019+ NAS, and downloaded large files to a Dell XPS 15 OLED laptop at three locations: up close, one floor up and two floors up. Up close it managed a blistering 715.5Mbps. This dropped to 303.7Mbps one floor up – which is still impressive for any router. It's two-floor-up speed of 30.5Mbps is rather low, but still better than other sub-\$200 Wi-Fi 6 routers.

Indeed, at \$149 the Mercusys MR70X represents something of a bargain. While we did miss having an app to manage the settings, how often does one really need to change them? It's faster than D-Link's \$300 EXO AX1800 and offers much better range than D-Link's \$199 EXO 1500.

Ultimately, its existence demonstrates that the Wi-Fi 6 market is now mature and that you needn't pay a large premium for an overpowered device to buy into it.

NICK ROSS

Fast and cheap. Few people will need to pay more.

★★★★★





\$179 | consumer.huawei.com/au

Huawei WiFi AX3 Quad-core router

An innovative router at an attractive price, but there are issues.

One of the many things that Huawei is synonymous with is computer networking. So, it's strange that this is the first consumer router we've seen from the company. It is also unusual in that it eschews the industry's traditional spiky space-spider and star fighter form factors in favour of a more furniture-oriented appearance. Indeed, the white body is literally L-shaped and only 1cm thick. The four, flat antennae fold up from the body but they're not very large, which gave us concerns regarding range.

Huawei's networking and manufacturing prowess means there are added bells and whistles on this router. While many of the innovation-based claims turn out to be reworded spin on well-worn Wi-Fi 6 benefits, there are still some genuine theoretical benefits (not all of which are theoretical). One of these manifests when the router's chipset matches that of other Huawei mobile device chipsets, a situation that it calls "Chipset Synergy." It describes this thusly, "Huawei Wi-Fi 6-enabled phones are able to send 6dB stronger signals back to AX3 in stable, 2MHz narrow bandwidth using Dynamic

Narrow Bandwidth technology, which is based on Chipset Synergy." It also uses its own, fast 1.4GHz "Gigahome" processor, which theoretically should boost peak speeds on a shared network. This is hardware we usually see on expensive, premium routers. Enhanced on-chip security is also included although it's not targeted at consumers: "Enabled by TEE (Trusted Execution Environment) and Microkernel, AX3 offers a secure area inside its main processor, where both software and hardware are used to protect the data. It is also CC EAL5 certified, meaning it could operate safely in a commercial environment, offering great security assurance to your devices." All good.

A less secure feature is the 'H' button on the top which allows one-click connection to a Huawei device that's held close. It also acts as a traditional WPS button. Uniquely, there's also NFC which automatically connects a (guest's) phone to your network just by tapping the router. You need to turn the latter off in a web browser if you don't want to use it.

Set-up is relatively straightforward when using the app. This also gives you easy

SPECS
Speed: Dual-band
AX 3,000Mbps |
Connectivity: 3x
Gigabit Ethernet
LAN plus 1x
Gigabit WAN | NFC
Features:
Parental controls,
QoS, Port
Forwarding.

access to connected devices and network health. And it enables you to limit speeds and set parental-control-style access settings.

We were keen to test performance so we used it to transfer large video files from a Synology DS1019+ NAS (on the ground-floor of a three-storey Sydney Town House) to a Dell XPS 15 OLED laptop. We did this up close, one floor up and two floors up. Up close it managed a whopping 779Mbps but this quickly collapsed to 39Mbps (first floor) and a pitiful 3.6Mbps (second floor).

If you live in a small, smart-looking, one-storey apartment the AX3 is attractive thanks to its unique looks and ease-of-access features. However, while \$179 is impressively low for a Wi-Fi 6 router (especially a quad-core unit) it's still not quite the cheapest or the quickest we've tested – the Mercusys on page 35 takes that award.

NICK ROSS

Nice design with some innovative features. But it's blistering up-close performance is matched by its poor performance at distance.

★★★★☆



\$550 | www.draytek.com.au

Draytek Vigor2927ac

A high performance business router with comprehensive redundancy and network management options.

Networking for small to medium businesses can be a remarkably complex affair, so Draytek aims to make life a little simpler with a range of routers and other hardware designed to be fast and easy to manage. The Vigor2927 is a feature packed, rack mountable, dual Ethernet router, with the ability to control your entire network. To try before you buy, Draytek has a very handy virtual demo of the router online at eu.draytek.com:12927.

The Vigor2927 comes in three flavours: no Wi-Fi, 802.11ac Wi-Fi, and Wi-Fi + VOIP (and a separate single Ethernet LTE model), but otherwise the rest of the featureset is the same. The router is built around dual WAN ports (though one can be reconfigured to LAN), for connecting to your internet service of choice. You also get five LAN connections, plus dual USB ports that can handle 3G/4G modems, storage, printers or temperature probes.

The key here is speed and reliability, and you can configure multiple internet sources for failover and load balancing (including from Wi-Fi and even dual USB 4G on different networks), to ensure your business always stays connected. The router

has a powerful inbuilt firewall, plus all the filtering and APP level bandwidth management options you could hope for, as well as the ability to handle 50 VPN (25 SSL) connections. Importantly, the 2927 Series has hardware acceleration available, which can be used to dramatically improve performance where needed, such as using dual WAN to more than double the 800Mbps NAT throughput to 1.8 Gbps.

For larger businesses or future upgrades, the 2927 series can also be the central hub controlling a network and can handle up to 20 Vigor Wireless Access Points, as well as 10 Vigor Switches. This can be achieved via the routers interface, or through the (free) VigorConnect or (paid) VigorACS management software.

We tested the Vigor2927 series with a range of Draytek wireless access points, a VigorSwitch P2121 switch, as well as a gaggle of NAS, IP cameras, computers and mobile devices. Our test model is the 2927ac, and we managed 653 Mbps from the Wi-Fi at close range, and up to 367 Mbps at 10m. We ran the 2927 through a battery of tests designed to simulate heavy network load, as well as internet dropouts, with and without

SPECS

2x WAN Ports; 5x RJ-45 1GbE LAN Ports; 2x USB 2.0; 802.11ac Wi-Fi; VPN Tunnels: 50 16 VLAN; NAT Throughput: 800 Mbps; VLANs: 16; Size: 241mm x 165mm x 44mm

hardware acceleration. The 2927 did an excellent job managing our network, providing failover internet, and prioritising important traffic, such as video conferencing, with no apparent bottlenecks. The hardware acceleration gave an admirable performance boost, especially when taking max VPN IPSec performance from 290 Mbps to 800 Mbps.

The in-depth feature set means getting to know the router takes significant time and effort, but between the wizards and online support there's no major stumbling points for even businesses new to larger networks. At this level the router interface or VigorConnect software is enough for network management, but the VigorACS software is well worth the cost for time savings alone for more complex networks – providing of course it's built using Draytek hardware.

The price of the 2927 is quite competitive with other dual WAN routers, especially if opting for the model without Wi-Fi.

LINDSAY HANDMER

A versatile router that offers excellent hardware accelerated performance, redundancy and management options without costing the world.

★★★★★



\$200 | samsung.com

Samsung 980 M.2 NVMe 1TB SSD

Samsung's 980 is an inexpensive M.2 SSD that lacks DRAM, but it packs the company's fastest flash yet.

Samsung's SSDs are widely regarded as among the most reliable and best-performing in the market, and the company hopes to extend that reputation with the introduction of the 980 NVMe SSD. Samsung's 980 is designed for everyday PC users and gamers, although with performance ratings six times that of a standard SATA SSD, it possibly appeals to lower-budget content creators, too.

Samsung's 980 also stands out with much more affordable pricing than the 980 Pro and 970 Evo Plus, a benefit borne of its DRAMless design that the company claims makes it the highest-performing DRAMless SSD on the market. Powered by the company's V6 V-NAND and an efficient DRAMless controller that first debuted in the Portable SSD T7 Touch, this

mix of hardware promises fast PCIe Gen3 performance and respectable endurance ratings.

Samsung targets the 980 at lower price points with capacities that include 250GB, 500GB, and 1TB models. With current street prices of around \$100, \$170, and \$200, the 980 hits the market with affordable price points at each capacity. That stands in contrast to the rest of the company's SSD families, many of which span from 2TB to 8TB and cost hundreds of dollars.

Samsung's 980 comes with TurboWrite 2.0, meaning it features a massive SLC buffer that's larger than the cache on the 970 Evo and 970 Evo Plus. This speedy buffer absorbs data at a faster rate before write speeds degrade as the workload spills into the native

TLC flash. However, the 980's TurboWrite 2.0 implementation is a bit different than the 980 Pro's; instead of a hybrid arrangement with both static and dynamic TLC caches, the 980 comes with just a dynamic SLC. This enables more cache capacity for the 500GB and 1TB models than the 980 Pro, but due to the 980's lower-end SSD controller, the SSD isn't quite as fast when the cache is full.

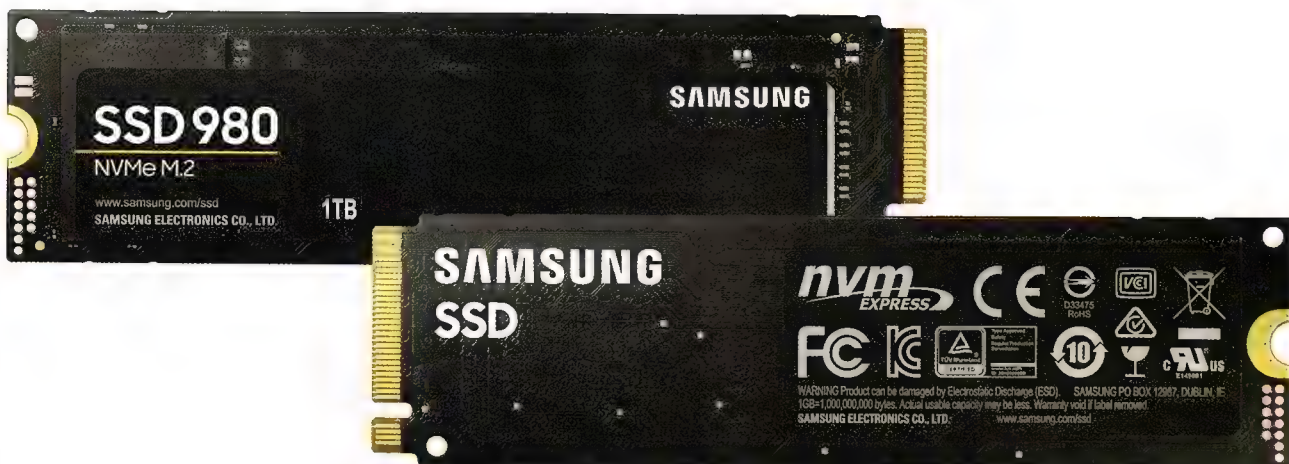
Interfacing with the host over a PCIe 3.0 x4 link, the 980 NVMe SSD can hit up to 3.5/3 GBps of sequential read/write throughput and even sustain up to 500,000/480,000 random read/write IOPS at its highest capacity. But, while peak figures are eye-catchers, the real key to application performance lies in the QD1 random performance rating. Samsung rates the drive with up to 17,000/54,000 read/write IOPS at QD1, which promises responsive performance in everyday desktop PC workloads.

Like the 980 Pro and 970 Evo Plus, the new 980 comes factory over-provisioned by roughly nine

"Samsung's 980 also stands out with much more affordable pricing than the 980 Pro and 970 Evo Plus, a benefit borne of its DRAMless design that the company claims makes it the highest-performing DRAMless SSD on the market."

■ Best result
■ On test

	Samsung 980 1TB	WD Blue SN550 1TB	Samsung 980 Pro 1TB	Samsung 970 Evo Plus 1TB	WD Black SN750 1TB	Crucial PS 1TB
Peak sequential read (MBps)	3,573	2,441	3,560	3,560	3,278	3,511
Peak sequential write (MBps)	2,842	2,017	3,345	3,345	3,024	3,317
Random read IOPS	16,616	10,883	12,436	12,436	9,530	15,108
Random Write IOPS	50,589	62,030	51,774	49,529	47,799	42,055



percent and is backed by a five-year warranty or up to the respective TBW rating, which varies based on the capacity of the drive (150 TB per 250GB). The 980 also boasts the same AES 256-bit Full Disk Encryption feature set that's compliant with TCG/Opal v2.0 and Encrypted Drive (IEEE1667) standards.

A closer look

Samsung's 980 comes in an M.2 2280 single-sided form factor with a black PCB. To keep the SSD cool, Samsung incorporated a few thermal solutions into the design. The heat spreader label on the back of the drive improves thermal dissipation to help combat excess heat, and the Dynamic Thermal Guard technology invokes thermal throttling if needed. The 980 also supports Active State Power Management (ASPM), Autonomous Power State Transition (APST), and the L1.2 ultra-low power mode to regulate overall power consumption. The controller also comes with a nickel-coating that the company claims reduces its operating temperatures by five degrees Celsius.

Speaking of which, Samsung's Pablo – an NVMe 1.4 compliant SSD controller – powers the 980. The company wasn't too forthcoming with deeper details on the controller. We believe it to be a multi-core Arm architecture that may be manufactured using its 14nm process, especially since the 980 Pro was so proudly touted for being manufactured on the company's 8nm process node.

The controller features half the NAND channels of the controllers that power the company's 970

"The Samsung 980 is definitely one of the fastest DRAMless SSDs to have passed through my hands."

Evo Plus and 980 Pro, which, along with the lack of a memory controller, helps save on cost due to less complex logic. Naturally, that comes at the expense of performance. However, to mitigate these performance bottlenecks, the DRAMless architecture uses host memory buffer (HMB) tech that leverages the host system's DRAM instead of an onboard DRAM chip to host the FTL mapping table.

This technology allows the controller to leverage a small portion of the host system's DRAM memory by using the Direct Memory Access functionality that's baked into the PCI-Express interface. The company programmed the SSD to use 64MB of system memory for the 980's needs, which is similar to other HMB drives on the market.

Each capacity of Samsung's 980 NVMe SSD comes with a single NAND package containing up to sixteen 512Gb dies. Samsung's V6 V-NAND TLC has a 2-plane architecture. While this is only half the number of planes compared to competing types of flash, Samsung says it has engineered the silicon to still provide speedy programming and read times.

Conclusion

Overall, the Samsung 980 is definitely one of the fastest DRAMless SSDs to have passed through my hands. Although the 980 comes without DRAM to save on production costs, the drive

harnesses Host Memory Buffer tech to accelerate FTL interaction, thus unlocking a level of performance that's competitive with many of the best PCIe Gen3 SSDs on the market. The 980's DRAMless architecture also makes for less than stellar sustained write performance, but its cache recovers very rapidly to ensure you won't run into too many slowdowns over the life of the product.

Samsung won't need to slash MSRPs after launch, either. Instead, Samsung actually valued its product accurately right out of the gate.

The Samsung 980 is a good pick if you don't necessarily need Gen4 speed but want to buy a product from a reliable brand that doesn't have a variable build of materials, meaning Samsung uses the same components even a year or two after launch. From its performance and efficiency to the 980 Pro-level endurance ratings and five-year warranty, the 980 offers a compelling mix of value for just a fraction of the cost of the company's other NVMe products.

SEAN WEBSTER

If you aren't looking for the best of the best like Samsung's 980 Pro but still want solid performance for large files or graphics-heavy games at a more affordable price point, Samsung's 980 is worth your consideration.

★★★★☆



\$220 | msi.com

MSI MPG Sekira 100R

MSI's newest entry in the case market is well thought out and includes nice quality of life features.

MSI is on a mission to impress with its ever-expanding lineup of cases. Unlike some makers that flood the market with a large and confusing range, MSI is taking things slowly and carefully. The new MPG Sekira 100R is a well-designed and great looking new case in the range.

At around \$220 (street price) it sits comfortably in the mid-range bracket, and has enough features to well justify its reasonable cost.

Technically it's a medium-sized version of the larger MSI Sekira 500P, yet it can amply contain motherboards up to E-ATX with room to spare. It shares the 500P's design aesthetic, which, to my eyes, is a pleasingly simple and stylish look with little flourishes here and there turning it into something that's easy to love.

Initially I was concerned the ventilation might be inadequate. The front has a full-sized cover (split attractively into a brushed aluminium top area, and tempered glass in the lower section) and air is sucked in via 2.5cm vents running from top to bottom along the edges. This design has proven restrictive in other cases I've built in, but the

width and length of the openings ensure very good airflow, while preserving its rather nice appearance.

Along the top there's room for two fans or a 240mm AIO radiator. If you're looking to mount a 360 AIO cooler you'll need to mount its radiator vertically in the front. The Sekira 100R ships with three 120mm ARGB fans in the front, and a single ARGB 120mm fan at the rear. They're all hooked into an ARGB controller board behind the motherboard plate, with one spare connector available, and the installed plugs are nicely taped in place so they won't get knocked out during a build.

There's an easily removable HDD mount for two drives, along with a SATA SSD mount inside, and another on the rear. They too both pop out easily if you're doing an M.2-only build, and the resulting cavity is plenty large enough for good airflow and the longest of graphics cards. The PSU cavity is a separate enclosure to the main area.

Overall build quality was excellent; MSI has done a great job with ensuring good paint

coverage, no sharp edges and screws and fasteners that go in easily. I did appreciate that the rear fan ARGB and power cables are wrapped up in velcro tape to keep things tidy.

The only downside to the case is that both side panels are held in place by tiny lugs and then the top panel clamps down and is screwed in to hold it all in position. That means the rear panel may fall off when you remove the top panel to get to the front panel, especially if it has the usual coils of spring-loaded cabled compressed behind it.

But a big plus goes to the front I/O ports. You get a pair of USB 3.2 and a Type C, as well as audio plus mic, and a single button that cycles the ARGB colours – fantastic for those with simple RGB tastes that couldn't be arsed installing an app for that purpose.

BEN MANSILL

The Sekira 100R is a classy looking with good airflow let down only by the poor panel attachment system.

★★★★★





\$200 - \$400 | Second-hand market

IBM Model M 1990

How does a 31-year-old keyboard hold up in 2021?

The IBM Model M is a classic. First introduced in 1985, it is the successor to the Model F, which is an equally sought-after vintage keyboard, if not more so. The Model F had a more difficult layout, but the Model M changed this and became more user-friendly. The Model M helped to create the modern-day layout – apart from the lack of Windows keys. It is one of the very first keyboards, if not the first, to include dual Ctrl and Alt keys, function keys, alphanumeric keys, navigation keys, numeric keys, and indicator lights.

The switches on the Model M make a keyboard enthusiast weak at the knees. They're so satisfying to press, and although they are obnoxiously loud, they're very fun to type on, at least for the person doing the typing. The switches are technically "memmechanical," but are seen as mechanical by many due to the way they work. Unlike the capacitive buckling springs of the Model F, these are a buckling spring over a membrane. The switch is pressed, the spring buckles, and this action makes a pivoting hammer contact the membrane sheet and actuate. For those who love clicky, tactile switches, the buckling springs are your endgame. They start off at a

somewhat low weight, and increase in intensity until the spring buckles with a satisfying "twunk" and the switch actuates, all in an instant. For typing, they're on another level compared to mechanical switches.

Gaming on the Model M has a few major drawbacks. The Model M has 2KRO (key roll-over), just like most membrane boards. This means that you can often only press two keys at a time, so if you want to press W, A, and Ctrl at the same time, the keyboard may detect the keypress as something different, or not at detect them at all. Most modern mechanical keyboards have NKRO, which means that all keys will be detected regardless of how many you are pressing. The Model M wasn't designed for gaming, and as such it isn't going to compete in this category. The Model F has NKRO due to it being a capacitive board, and despite the strange layout it is often seen as superior due to this. We're hopefully going to get our hands on a Model F over the coming months/years, so we will see how relevant it is in the modern world too.

The build quality of the Model M is astounding. 30 years later and it looks and works like it just came from the factory. The hard beige/gray plastic of the case is indicative of the style of PCs back in the 80s. The

plastic surrounds a large metal plate, and this plate houses the PCB and gives the keyboard a crazy weight. If you want a keyboard to double up as a bludgeon, this is for you. The keycaps are PBT and have a nice grayscale theme. They're rather good quality for a set of original keycaps, but there are burs from the manufacturing process.

Overall the keyboard is a fond memory for office workers from 1985 up until the new millennium. Membrane keyboards then became the cheaper alternative, and although Model M boards are still being produced by Unicomp, they're using old tooling and are just not quite the same. This keyboard is a part of history, but it still holds its own in many aspects. Is the Model M still relevant in 2021? If you're a typist, you will struggle to find better. If you're in your mid-30s or older, you'll relive your nostalgia. If you're due a zombie apocalypse, you have a weapon. Is it still relevant? Yes – unless you're a pro gamer of course. DAVE ALCOCK

Buckling spring switches; built like a tank; changed the layout of modern keyboards; great typing experience; removable cable.

★★★★★



\$299 | rog.asus.com

Asus RGB Falchion 65%

Small, but perfectly formed.

Little keyboards have never really taken off, and I'm not sure why. Using one, initially the mind will trick you into thinking everything is smaller, but the keys are generally the same size as you'd see on a full size keyboard, as is the spacing. Various key combos are used to replace the missing physical keys. These are indisputably the ultimate space saving typing and gaming tools.

Asus's 65 percent-sized Falchion still packs in all the full-size features. The keys use a Cherry switches (Red or Blue) and a high quality PBT plastic that feels extremely solid and durable. The raised keycaps let a little light bleed through, but not annoyingly. Running along the left edge is a touch-sensitive slider, defaulting to volume, but which can be remapped. The always-on light strip upon it also shows battery life. Neat, though I was inadvertently changing the volume until retraining my brain not to rest my hand on that side of the keyboard. Along the top would be a better spot.

Wireless is a stable 2.4GHz via a dongle, and it plugged and played nicely, including on a Mac. The RGBs are controlled via hotkeys and your setting saved to onboard memory, or you can install the Asus Armoury Crate app to set up macros and customise RGB and all other functions.

It's pricey, but so are all high-end wireless keyboards, and the quality and feature set here truly is premium. It even comes with a seriously decent hard cover to keep the dust out when not in use, or to protect it if you like the idea of this as a portable laptop improver.

BEN MANSILL

Small in size without big-feature compromises.

★★★★☆



\$55 | www.tenda.cn.com/au

Tenda E30 AX3000 and Bluetooth 5.0 PCI Express Adapter

The cheapest Wi-Fi 6 product we've seen. But is it a bargain?

Tenda is a big-in-China brand that's steadily increasing its footprint on these shores. So far, its products have impressed us with their value and ease of set-up. Now, here's the company's Wi-Fi 6 PCIe adapter for connecting desktop PCs to Wi-Fi 6 wireless networks (and Bluetooth devices). It's half the price of D-Link's rival, so should you buy it?

Installing the PCIe card is straightforward. You simply plug it into the x1 PCIe slot and connect the optional Bluetooth 5.0 cable to a USB header on the motherboard. You then attach two antennae directly to the backplate. If you use a small, home theatre-style PC, a low-profile backplate cover is also included. We then turned on the PC and didn't even need to enter a network name or password as Windows already knew the information.

Our PC sits two floors above our router in a Sydney town house. Using Speedtest, the E30 managed to max-out our internet connection with speeds of 100Mbps down and 20Mbps up. The ping registered at 11ms when it can normally manage 8ms, though. However, when we tried to transfer a large file from our NAS, a highly variable connection only averaged 25Mbps – way behind D-Link's 316Mbps.

At \$55 it's hard to complain. If you just need a reliable, Australian-internet-grade connection to a distant PC, this is a high-value way of achieving it. However, D-Link's double-the-price alternative (which comes with stronger, tethered 'bunny ears' antennae and Bluetooth 5.1 compatibility) won't break the bank and offers significantly better performance.

NICK ROSS

Cheap and cheerful but offers poor performance with large file transfers at distance.

★★★☆☆



\$479 | en-au.sennheiser.com

\$159 | huawei.com

Sennheiser IE 300

Pocket sized perfection.

After spending so long in a True Wireless state for music on the go, it's almost quaint to unroll the IE 300 from their carry case.

Sporting an over-the-ear 'flexible hook' cabling system, getting the IE 300 on and locked into your sound seashells and sitting just right is a bit fiddly. Even after several weeks of regular use, seating the buds deeply into your ears then wrangling cabling over the top feels a little counter intuitive. That said, once they're in they're staying put and are barely noticeable on the head; though glasses wearers may object. As well as the traditional silicone ear adapters there's also a memory foam set that we highly recommend switching to for a tighter fit and increased passive isolation.

The IE 300 are an absolute delight to listen with. They enthusiastically gobbled up everything we threw at them and delivered it back with precision. Even our usual go-to artists – Blackpink, GoGo Penguin, Chic, Darkside, Fleet Foxes, Kiko Loureiro, Muse and The XX among others – that generally highlight inconsistency, gaps and dead spots across the range didn't challenge these buds. In the end we just chose our favourite tunes and the IE 300 loved them too.

Don't fall into the trap that audiophile quality headphones are reserved for lovers of classical who just want to hear the sweat dripping off the conductor's baton, these buds will take whatever genre of music you're into, make it sound better than you've ever heard it and do what music does best; put a huge smile on your face.

TROY COLEMAN

A little fiddly to quickly wrangle onto the ears but it's worth the effort for this level of fidelity.

★★★★★

Huawei Freebuds 4i

Going the distance.

It was only recently that wireless buds gave you more than three or so hours of listening time before running flat. Apple's AirPods are good for around five hours – but the newest iteration of Huawei's budget line of FreeBuds delivers an extremely welcome 10 hours. That's well in excess of anything we've previously tested, and having run them flat several times over the last couple of weeks it's an honest promise.

That best-case situation is with ANC off, and volume at 50 percent. It falls to a still impressive 7.5 hour battery life with ANC on, and the portable charging case will top it up quickly with a small amount of juice to spare. That's something like 22 hours of non stop music in one package.

The buds (black or white, 5.5g each) have a gloss sheen which makes them slightly slippery to remove from the case, but seal in the ear nicely. They are immensely comfortable, more-so than anything I've tried before. It's easy to forget they're there. ANC is better than expected for a budget product, and there's also an awareness mode for hearing the car that's about to run you over.

The EQ is tailored to pop music and the bass is a little thin, but I was never disappointed. For audiobooks the EQ is just about perfect. In test calls the phone mic was good enough, even in windy conditions. Touch sensors on each bud are configurable for your preferred functions.

At its launch RRP these are fantastic value, and the generous battery life is so very welcome.

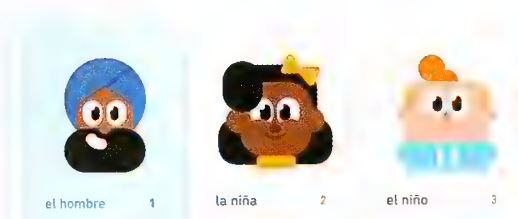
BEN MANSILL

The new endurance champ with better sound that it's entitled to at this price.

★★★★★

2 IN A ROW

Which one of these is "the man"?



Awesome!

REPORT

CONTINUE

Duolingo \$Free or US\$7 per month | <http://duolingo.com>Babbel \$9.99 per month | <http://babbel.com>

Duolingo vs. Babbel

Learning whole new languages online has never been easier.

Learning a new language as an adult can be a tricky proposition, especially if you live in a monoglot culture and don't get the chance to practice.

Apps and services that promote language-learning can come in handy here, offering daily lessons to learn new vocabulary and reinforce old lessons, so that when you do get the chance to use your new language skills, they're on the tip of your tongue.

Prominent among these services are Duolingo and Babbel. They're both popular ways of learning another language, but each takes a rather different approach.

The first major difference is in

pricing: Duolingo is free. Or at least a version of it is. The free software gets you full access to its lessons – and that's it. If you want to remove ads, get offline access, make unlimited mistakes, and actually track your progress, you need to sign up for a Plus account. This costs US\$7 a month, and there's a two-week free trial to see whether it's right for you.

Babbel gives you a week's free trial, but makes you sign up for a subscription plan before the trial starts, so you have to remember to cancel at the end of the seven days if you decide it's not for you. There are two levels of subscription – a Babbel App sub, which gives you access to all the online streaming lessons (from

Cartoon-style graphics lend Duolingo a learn-while-having-fun air.

\$9.99 a month, if you sign up for a year), and Babbel Live, which gets you that plus access to live virtual classes (the cost depends on how many classes you attend).

The approach the two apps take toward learning a language is very different. As you can tell from the description of the subscription levels above, Babbel takes a traditional lesson-based approach, with modules and a logical structure, where basic vocabulary is taught first. Duolingo treats it as a game, with bite-sized lessons that focus on real-life goals, and leaderboards that pit you against your friends in competitive language-learning, and is organised around "skills" – short units on a single subject, such as the weather, or your family.

This is the main differentiator that will send some learners to one app and others to the other: Do you learn best in a structured environment with a "teacher"

"Do you learn best in a structured environment with a "teacher" figure? Or are you more likely to retain the information in a 10-minute session on the couch with a cartoon owl?"

Match the items

hola

bye

yes

hello

thank you



figure? Or are you more likely to retain the information in a 10-minute session on the couch with a cartoon owl? Duolingo's approach is actually a bit deeper than that. While the cartoon owl is a feature, there's a method at work behind its unusual working practices. In a study carried out by Duolingo itself, the median amount of time Duolingo learners with no prior knowledge of a language took to reach "intermediate" level was half that of college students ("Intermediate" is defined as reaching the fifth checkpoint in Duolingo, and the A2 proficiency level for college students).

Mind-altering effects

Now, obviously, research that's been carried out by companies about themselves is always suspect, and "company says own product is good" should never be a headline, but if there's a sniff of truth that using a free app is remotely as good as doing a college course, then really we should all be doing it. Research (proper research, this time) supports a link between bilingualism and cognitive flexibility, plus increases in alertness, empathy, creativity, and originality. The Sapir-Whorf hypothesis suggests that the structure of a language affects its speakers' world view, and therefore people's perceptions are relative to their spoken language.

Babble offers users a more traditional lesson-based, logical structure.

So, change your language, and you literally change your mind.

That's not helping us compare these two apps, though. Babbel's interactive dialogues are based on realistic scenarios designed by linguists, with the idea that, if information is seen as relevant to the learner, it's more likely to stick in the memory. Duolingo wants you to remember what you've been taught, too, so you're frequently required to go over skills you've already mastered. Duolingo also motivates you to keep going with "streaks" – essentially, it tracks the number of days in a row you successfully hit your goals in the app – but the sentences it has you memorise are just as likely to be nonsense as they are useful, with few explanations about why it wants you to learn about snakes eating cakes, or taking your pants off – you may learn advanced words before you know the basics. Duolingo's audio, too, sounds auto-generated and unnatural, whereas Babbel's is more realistic.

Perhaps this is the reason Duolingo can offer lessons in 38 languages to Babbel's 14. The hand-crafted approach may offer more realistic scenarios, but you never know when the Spanish for snake or pants will pop into your head just when you need it. Duolingo offers instant grading for all its lessons, while Babbel uses review sessions to check that you're retaining the vocabulary.

As far as apps are concerned, Duolingo offers them for Windows, Android, and iOS, while Babbel offers them for Android and iOS only – both services can be used perfectly well through their respective web pages, however.

The differences between these language-learning services run deep, even though they help you work toward the same goal. It all comes down to how you like to learn, whether a formal teacher and classroom setup is more likely to impress the information into your mind than a videogame-like system that encourages you to chuckle at the nonsense it gets you to translate, and compete with your friends via leaderboards. Would you thrive in a calm, professional environment (Babbel), or do you prefer the instant feedback of bright colours and loud noises you get from Duolingo? That's the kind of question that free trials were made for.

IAN EVENDEN

DUOLINGO

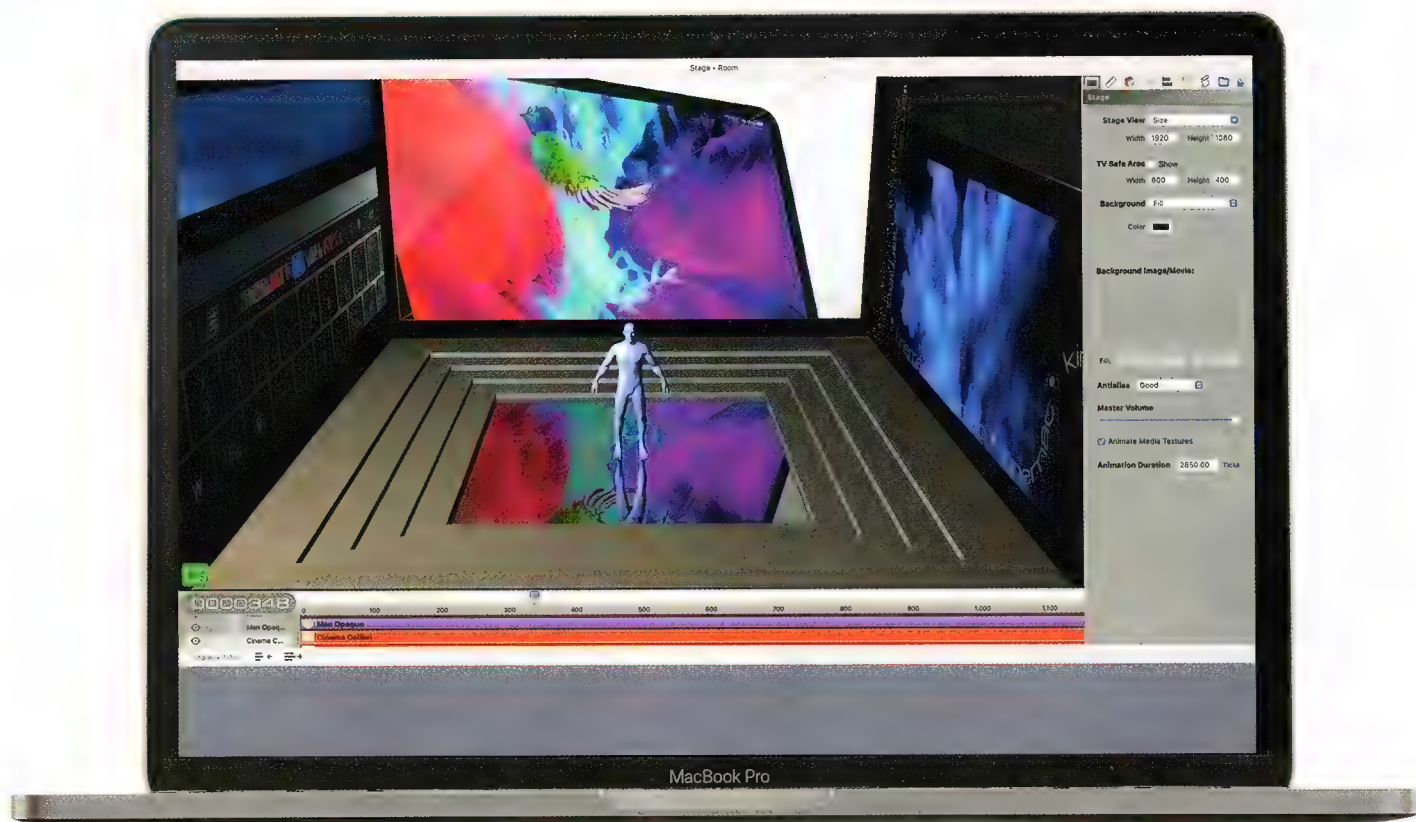
Game-like structure and competitiveness enhances learning for some.

★★★★☆

BABEL

A tailored approach to languages, with actual lessons.

★★★★☆



Needs macOS 10.15 or later | US\$99 for single-use licence | softube.com/kinemac

Kinemac 2.0.3

Create high-quality 3D motion sequences for your video projects.

Kinemac 2.0.3 is a 3D modelling and animation app that's designed to help you create motion graphic sequences for video projects. You can use it to present clips or stills on a series of virtual 3D screens to create eye-catching title sequences for your YouTube channel. The app offers a range of preset 3D shapes that you can add to your virtual TV set (or stage), and it's a doddle to drag and drop your own clips and stills onto the various sides of a 3D cube for example.

You can also create your own 3D text by importing and extruding an .SVG file or even import more complex 3D models (such as a human figure) as OBJ files (geometry definition file formats). Once you've built and lit your virtual set, you can use animatable cameras to add extra motion to your rendered video sequence (up to 4K resolution). Thanks to a control handle and a target icon its easy to control the movement of each virtual camera as it travels through your 3D set.

If you've used a 3D modelling app before, Kinemac's workspace will look familiar. It has multiple views that enable you to create and animate objects in 3D space. If you're not so familiar, Kinemac's website offers comprehensive step-by-step tutorials. Even if you are an old hand at 3D animation, you'll still benefit from following the tutorials.

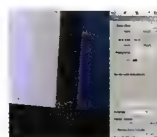
When it comes to animating an object Kinemac uses keyframes – like most other 3D animation apps. Keyframes describe the changing behaviour of an object in time, such as its position in space or its angle of rotation. In most apps, you need to change the object's position and then set a keyframe in the timeline. However, with Kinemac you need to set a keyframe first and then change the object's position. This 'back to front' approach is a less intuitive way to animate objects, especially if you're familiar with using keyframes in apps such as Photoshop's Motion workspace.

To rotate or scale an object most

Drag and drop clips and stills on to your virtual TV studio's 3D geometry and animate camera moves.

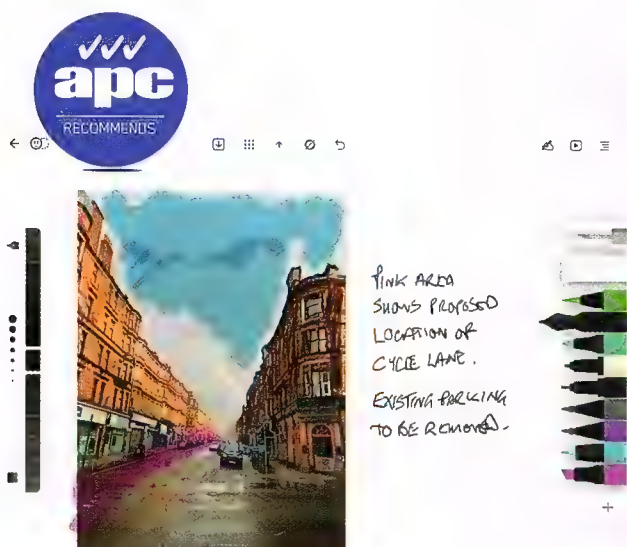
3D apps have easy-to-access selection handles attached to the object. These handles have colour coded x, y and z arrows that enable you to drag the object around in 3D space. However, with Kinemac you need to use keyboard combinations in conjunction with the mouse to rotate or move an object. Alternatively, you can type values into boxes in the Inspector. Neither of Kinemac's object manipulation controls are as handy as having the rotate, translate and scale control handles that most other 3D apps offer, which makes it more challenging to animate an object in Kinemac. That said, once you get used to the app's idiosyncrasies, you'll be able to quickly produce complex looking title sequences for your video projects.

GEORGE CAIRNS



Make 2D text follow a specified path on 3D geometry.

Thanks to preset shapes and drag and drop assets, you can quickly create and decorate a virtual set. Animating it takes more time. ★★★★★



The latest version of Flow enables you to combine its drawing tools with photos and other images.

From \$3.49/month | moleskinestudio.com | Needs iOS 13 or later

Flow by Moleskine Studio

An endless canvas for artists

Flow is an artist's sketchpad with customisable brush presets and gestures, and an endless canvas for images of any width.

The second major version brings a lower price tag: if you buy the Studio Bundle for \$32.99, you get Flow plus the Timepage calendar app and Actions to-do app. The app is \$32.99 per year on its own.

Flow's endless canvas can now flow vertically instead of horizontally, and the new Pencil Case mode takes the tools away from your iPad screen and displays them on your iPhone instead.

You can add images to a document from Photos or Files, including supported cloud storage services, and you can take photos from inside the app and draw on them. You can paste from other apps or from the Universal Clipboard, and you can drag and drop between apps in tiled iPad windows. For teams, the killer feature may well be the new real-time collaboration. Two or more Flow users can work on the same document at the same time, and if you'd like to chat while you create there's picture-in-picture FaceTime and Zoom for bigger groups.

The collaboration features make for a powerful incentive to go with the Flow.

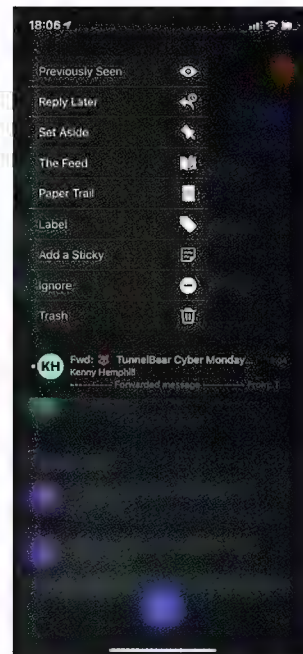
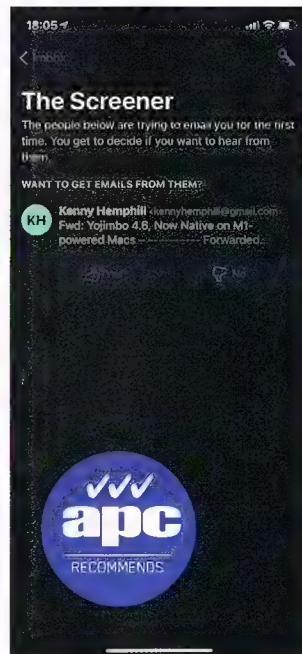
CARRIE MARSHALL

Collaboration tools make Flow more than just a sketchbook.

★★★★☆

The Screener checks in when you have an email from a new sender.

You can choose to set messages aside to read later.



US\$99/year | hey.com | NEEDS iOS 13 or later

HEY Email

Pricey but productive email service

The obvious question here is does Hey offer enough to make it worth the hefty price tag?

Hey focuses on privacy and productivity. The Screener allows you to control who can send you messages. When an email arrives from someone who hasn't messaged you before, Hey asks you to confirm you want to receive it first. Hey also blocks trackers used to see if you've opened a commercial message. You can set aside messages to read later or reply to later. The inbox is split vertically, with all unread emails at the top. And you can group messages together – such as all unread – and read them like a social media feed. There's also an attachment library, contact pages, and The Paper Trail that acts as a repository for receipts.

You can change the subject of a thread (and only you will see the change) so that it's meaningful to you, and add private notes to messages.

Hey supports iOS 14 widgets, share sheets, and Dark mode. As Hey is an email service, not just a client, you can't use it with anything other than a hey.com email address, though you can forward mail to it.

If you're a heavy email user and don't need the bells and whistles, such as shared mailboxes in Outlook, it could be the email service for you.

KENNY HEMPHILL

Relatively expensive, but its features are worth it. Hey is an email service unlike any other.

★★★★☆



Android | Free

Meals of Mercy

Cure for apathy.

If, like me, you're not having much luck with food for yourself, perhaps try food for others. Meals of Mercy is an app set up by the Muslim Australian Aid charity and lets you make micro donations to help feed those in need. You can choose how many meals you can afford to provide at the time, and all donations are tax deductible. I like the idea of having an app on my phone where I could give a few dollars here and there while having my own meal to make sure someone else gets one. It's also easy to use, fairly nice to look at, and has helpful extra info for both tax and religious purposes. My one caveat is I have a general mistrust of charities. I did some research and didn't find anything outlandish but I always recommend checking out who your money is going to. Not all charities are created equal. Additionally if you can convince one billionaire to give up a percent of their wealth you'll be doing immensely better work.

★★★★★

HOPE CORRIGAN

"I could give a few dollars here and there while having my own meal to make sure someone else gets one."



Android | Free

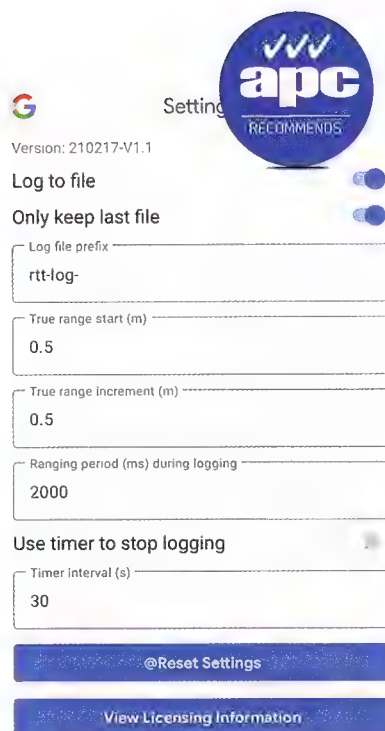
Symptom Tracker, Allergy & Food Diary - MoodBites

Limited menu.

I often find my guts to be unhappy with me but rarely can I decipher the cause. When I stumbled across this app, I was actually pretty excited. Maybe I could finally work out what food is setting me off, or at least start to nail it down. To do this you enter your data for every meal, including what you ate and how it made you feel. It has a bank of auto-filling foods it will pull from that will automatically also highlight allergens for you. It's a neat idea, but unfortunately the list isn't particularly robust. For example, I can't tell the app that I had lactose free milk, rather than regular milk. I also couldn't tell it about my pepperoni pizza as a whole, and had to settle for listing the ingredients – which would have been fine but things like pepperoni, pizza base, dough, etc were not present. I think when this gets fleshed out I see potential, but for now it's a bit too bare bones to help me find my fiendish foods.

★★★★★

HOPE CORRIGAN



Android | Free

WifiNan-Scan

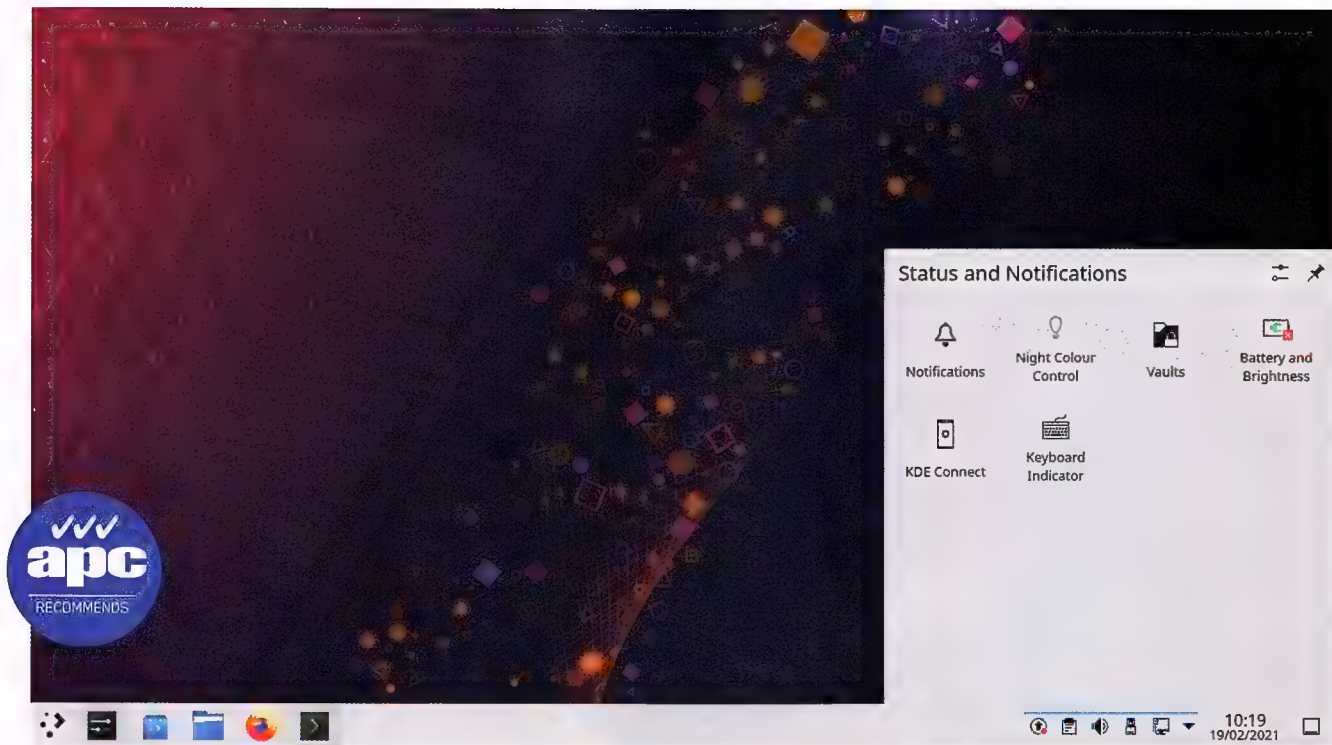
Fanscan.

This app is incredibly niche and may only be truly helpful for developers, but I think it's something interesting for anyone tech-curious to play with. What it does is allow two phones with the appropriate chips to connect, and relay information. One acts as a publisher, putting out the service, and the other subscribes to it. While the app is working, both users can send messages to each other. The subscriber can view cool information like how far away the other phone is. That's basically all this app does, so it's mostly useful for developers who need that info but I like that there's basically no risk of messing something up. It's a small peek into the window of a very specific tool our phones can be used for, as well as a bit of warning for how easy this information is to see. Worth it for anyone curious about this tech.

★★★★★

HOPE CORRIGAN

"While the app is working, both users can send messages to each other. The subscriber can view cool information like how far away the other phone is."



Linux | <https://neon.kde.org>

KDE neon 5.21.0

Jonni Bidwell has had it with Gnome, at least for this page, where he dabbles with KDE's latest desktop delights.

Despite the plethora of KDE distros around – from Kubuntu to KaOS to PCLinuxOS – some people still haven't heard of KDE neon. Any distro working on a fix release cycle is going to have problems keeping current with KDE. The KDE Applications suite is updated every three months, as is the Plasma desktop (roughly, and rarely in cadence with the applications) and the underlying KDE Frameworks libraries see a new release every month. So distros – conservative ones that don't like to break things at least – will tend to stick with older KDE technologies.

KDE neon wants to showcase the latest Special K, but to do so on a reliable base. So it's built on Ubuntu 20.04, but has its own repos for the applications, frameworks and Plasma trifecta. It goes to pains to point out that this makes it not quite a distro, because it doesn't offer any software outside of the KDE aegis (but that won't stop us labelling it as one because "software repository" sounds odd – Ed). This might put you off, or it might intrigue you, but we think you should at least check this out. If your last memories of KDE was the clunky, handles on everything widgetry of KDE 4, then you're

in for a refreshing surprise.

The Plasma desktop, we've often said, is a thing of beauty. It's also lighter and more traditional than Gnome, and in its latest 5.21 iteration includes a fancy double-pane application launcher, improvements to the svelte Breeze theme and a new system resource monitor for those KDE users who like to keep a close eye on proceedings.

A great deal of effort has been invested in getting the Plasma Wayland session on par with X11. KDE has some nice desktop effects and the team has been making sure Kwin (the window manager) renders these as smoothly with Wayland as it does in X11. KDE remains as configurable as ever, so if you don't like these you can turn them off. But we found them not at all distracting, and actually rather pleasing. QtQuick is used for rendering, so these effects shouldn't tax anything but the oldest of hardware.

The initial install occupies less than 5GB, but besides a lovely desktop you don't get much. Fire up the Discover package manager though and you'll soon find everything you need. In theory you can install anything from the Ubuntu repos, but it's possible that this

We used to mock KDE's slightly weird abstract backgrounds, but this one's really quite nice.

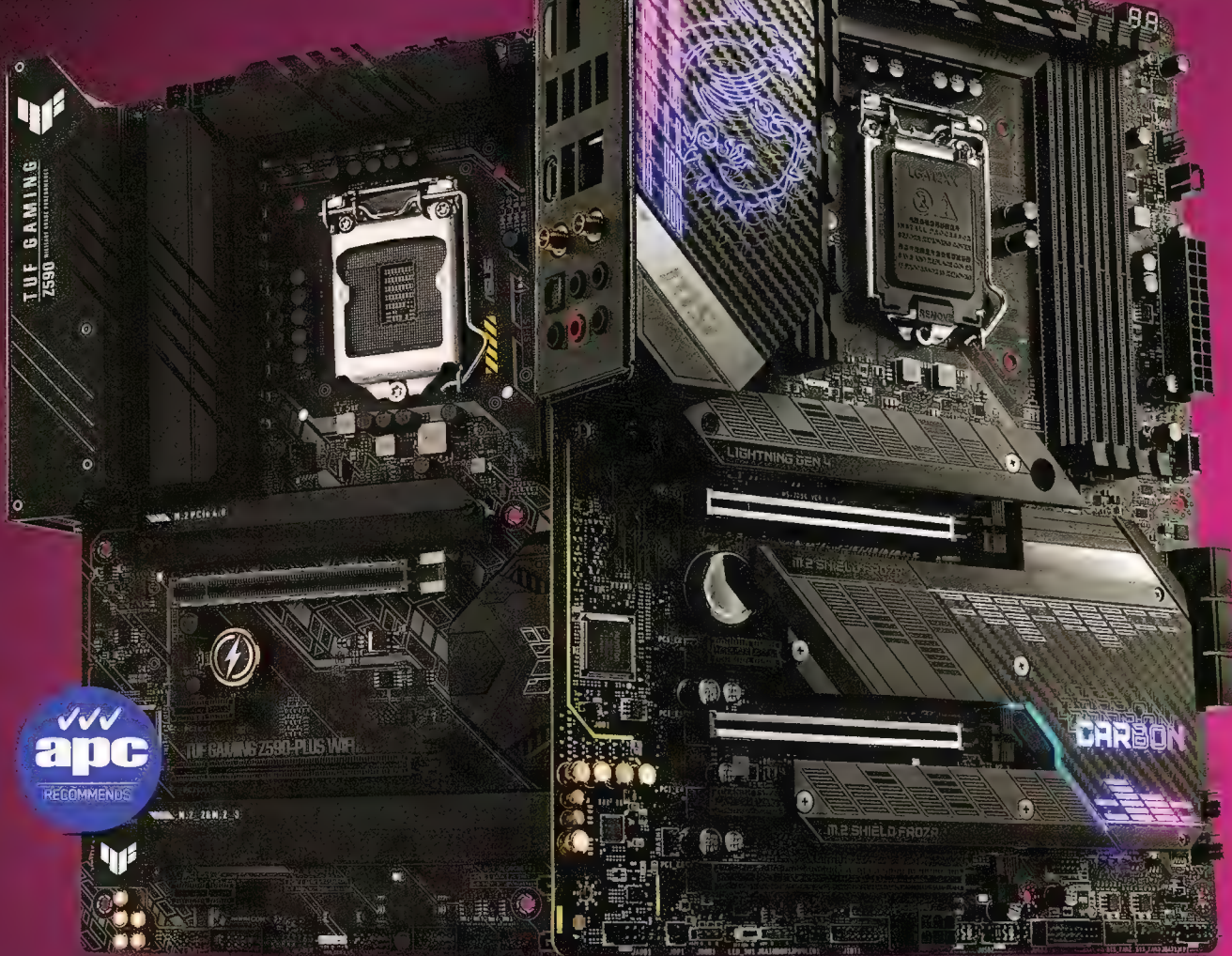
won't work (at least for some Qt software) because of newer libraries and such. Even if you don't like KDE you should probably like KDE connect, which enables you to receive mobile notifications on your desktop, as well as reply to messages, control music and all sorts of other things.

There's a lot to like here, from the effortless Calamares install to the peculiar pleasure that comes with a having a desktop that no modern distro could (easily) imitate. Even if you don't end up using it forever it might sway you to try other KDE-based affairs or Qt applications. If you really want to see bleeding-edge, check out the Testing or Unstable editions, which use Qt 6.0. But don't expect them not to break.

If you fancy being a KDE developer, then there's an edition for that too. This has all the pre-release Qt 6.0 stuff as well as all the libraries you'll need to start making your own beautiful applications.

Excellent showcasing of KDE. You might not use it as a daily driver, but it's well worth checking out nonetheless.

★★★★☆



LABS ROUNDUP

Intel Z590 motherboards

Feature rich motherboards
built for demanding CPUs.

Intel's 11th Generation of processors have landed! If you read our review of the i9-11900K in our previous issue, you'd have seen that while it performs well for the most part, it runs hot and it consumes a lot of power. The i5-11600K and likes of the 11500 and 11400 are much more appealing and will sell well, as will Z590 motherboards. They introduce some desirable features and are built to cope with the tough demands of Rocket Lake CPUs.

Perhaps the most noteworthy inclusion is native PCIe 4.0 support – finally! This means parity with AMD and that the latest and greatest SSDs can reach their full potential. The Z590 chipset also includes a welcome doubling of the CPU-to-chipset DMI bandwidth. This helps to alleviate any potential bottleneck that may occur if you're running several chipset-connected devices, including M.2 drives. Most Z590 models support much faster memory, well over DDR4-5000 in some cases,



thanks to the inclusion of a new memory controller divider, usually referred to as Gear 1 and Gear 2.

Premium budget

Though of course not all boards support all features, the mid and high-end boards will include features such as WiFi 6E, native 20Gbps USB 3.2 and Thunderbolt 4. This kind of connectivity will help to keep the platform relevant for years to come. Another key characteristic is the inclusion of strong VRM circuitry, which is necessary given the peak power consumption requirements of the i7 and i9 CPUs, and particularly the latter when Adaptive Boost is enabled. CPUs that can pull 300w or more without even being considered overclocked means you need a strong foundation. Some of the

cheaper Z590 boards have VRM solutions that wouldn't have been out of place on high end boards from just a few years ago.

Given the upwards trend in motherboard pricing over the last couple of generations plus the ongoing effects of the pandemic, we had fears that we'd see another jump. Thankfully, partly due to the stronger Australian dollar and despite semi-conductor supply issues, we are happy to see that pricing is better than we expected. There are many Z590 boards available for well under \$300.

Testing the Z590

For our testing, we ran the motherboards under both 'light' and 'heavy' loads. We've done this specifically to analyse how the board performs under default conditions, as well as how it handles an 11900K with Adaptive Boost enabled and the

power restrictions removed. The latter is a stern test of the motherboard, and it reveals some interesting differences in peak power consumption.

Picking the winner of a motherboard roundup is usually difficult, especially in the mid-range class. A single feature here or a percentage point benchmark win there might not make a lot of difference in the grand scheme of things. Brand loyalty will likely weigh just as much on your choice of board. We think any of these boards will serve you well. So, if you've made the decision to grab an 11th Gen processor, you can be assured that you'll have a solid foundation for your new system and you'll be getting some cutting-edge I/O features. Read on as we take a look at a selection of the best mainstream Z590 motherboards!



\$479 | www.asrock.com

Asrock Z590 PG Velocita

Challenging the sub \$500 market.

Say hello to the Asrock PG Velocita! It's a new product family and an evolution of the Phantom Gaming brand. It sits in between Asrock's mainstream ranges and the high end Taichi. Much like the MSI and Asus boards, it aims to find a balance of premium features without the top end bells and whistles that separate the sub-\$500 boards from those with ever steeper price jumps. It's a board we were excited to check out.

The Velocita features a busy looking grey, black and red theme complete with a little PCB inside the chipset heatsink. It's a really bold design with its splashes of RGB and attention-grabbing graphics. Will it appeal to all? Maybe, maybe not, but to us it looks good. It features the usual 3x M.2 slots and six SATA ports.

We're spending a lot of time examining the VRM designs of all the tested boards as it is central to the performance of 11th Gen CPUs, particularly the 11900K with Adaptive Boost enabled. The Velocita includes a 16-phase VRM with 60a chokes. This is more than

enough current to drive an AVX loaded 11900K. The heatsinks are on the chunky side but we feel that Asrock could do a little better job with them, both in terms of surface area and their aesthetic. Under a full AB load, the VRM returned a temperature of 69 degrees, which is a good result. Although it's one of the warmer boards, it is well within spec.

The rear I/O is a strength and an area Asrock usually equips well. About the only thing missing is a USB Gen 2x2 port though there is a header for one. Two Gen 2 ports are joined by six Gen 1 ports and two 2.0 ports. Networking duties are handled by Killer controllers, the only board in the roundup to come with them. Note that big blue Intel now owns Rivet networks, so these can be considered Intel controllers. Killer E3100G 2.5G and Intel I219V controllers are joined by a Killer AX1675X Wi-Fi 6E controller. It's the only board in the roundup to include dual LAN.

The Velocita performed as expected across our benchmark suite, and proved to be quite strong under lightly threaded

SPECS
LGA 1200 socket;
3x M.2; 6x SATA;
1x USB 3.2
Gen2x2, 2x USB
3.2 Gen 2, 10x
USB 3.1 Gen 1, up
to 4x USB 2.0; 1x
HDMI, 1x DP; Killer
Wi-Fi 6E; Killer
E3100G 2.5G and
Intel I219V 1G
LAN; Realtek
ALC1220 7.1
Channel HD Audio;
ATX Form Factor.

and gaming loads. We believe Asrock tends to be aggressive with its secondary and tertiary memory as the bandwidth-sensitive 7zip benchmark shows the Asrock performing particularly well. We saw a lot of variation in the PCIe 4.0 SSD test, where the Asrock clearly has a bit of BIOS tweaking to do to catch up, though in real world 'feel' this won't be noticeable.

The Velocita is very competitive in its price range, Throw in dual LAN and a couple of nice additions such as a GPU retention bracket and USB PCIe bracket too. We like its design and connectivity features. Asrock usually finds a way to add superior features and specifications without charging exorbitant prices. We do feel the Velocita is a BIOS update or two away from reaching a state of maturity. That's just a matter of a little tuning. If you've got \$500 to spend the Asrock Z590 PG Velocita is a lot of board for the price.

At under \$500 the Asrock competes well against boards costing more.
★★★★☆



\$379 | www.asus.com

Asus TUF Gaming Z590-Plus Wi-Fi

Not everyone needs an ROG or Strix board.

The Asus TUF Gaming Z590-Plus Wi-Fi is Asus' entry-level gaming board. It slots in below the high-end ROG and mid-level Strix series. The focus of TUF products has shifted away from the earliest military-themed Sabretooth branded boards complete with extended warranties to a more budget gaming tier today. Though the reliability aspect remains, it seems to be more of an aesthetic these days. The TUF Gaming Plus is positioned as simplified and affordable option for a mainstream gamer.

The TUF Z590 Plus features a fairly simplistic design with minimal RGB and the trademark TUF splash of yellow. You get three M.2 slots, with the topmost one supporting PCIe 4.0. There are six SATA ports. Four of them are vertically oriented which may not appeal to all. There are no real surprises with the layout and the white fonts add a small touch of class to the overall look.

The TUF Gaming has a decent but not spectacular 14+2 phase DrMOS power delivery system. There are 4- and 8-pin power connectors plus heatsinks that perform well. A stress test returned a VRM temperature of

SPECS
LGA 1200 socket;
3x M.2; 6x SATA;
1x USB 3.2
Gen2x2, 2x USB
3.2 Gen 2, 5x USB
3.1 Gen 1, 6x USB
2.0; 1x HDMI, 1x
DP; Intel Wi-Fi 6;
Intel I225V 2.5G
LAN; Realtek ALC
S1200A 7.1
Channel HD Audio;
ATX Form Factor.

just 60 degrees which surprised us. We expected higher. This is probably due to the fact that the Asus was quite power thrifty, returning the lowest power consumption reading under both default and Adaptive Boost loads. So, while the VRM is perfectly adequate, it's not a board you'd really want to smash out hour after hour of AVX512 rendering.

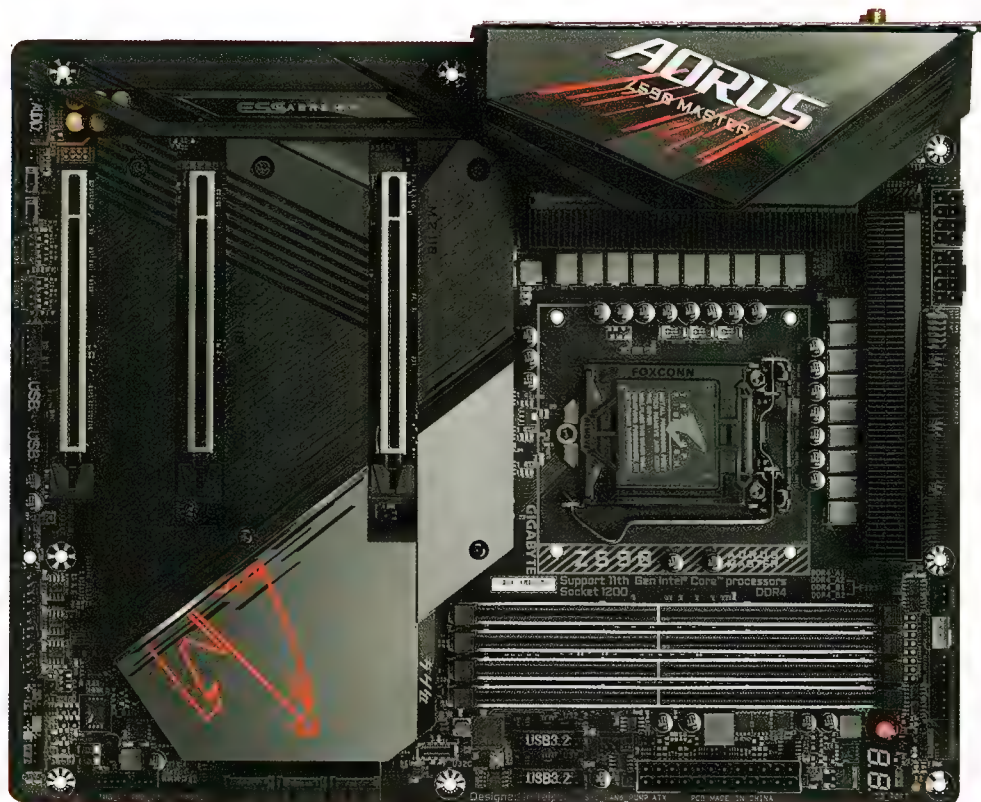
The rear I/O is on the basic side. We are happy to see a USB Type-C 2x2 port, otherwise there are no surprises. You also get two USB 3.2 Gen2, two 3.1 Gen1 and two 2.0 ports. Seven USB ports in this day and age is the bare minimum, though in fairness you can add more via case headers. Wi-Fi 6 (not 6E) and 2.5G Ethernet will be adequate for a typical gaming system. A budget Realtek S1200A codec takes care of the audio duties. You also get DP and HDMI ports. It's better to have them as an option rather than not to.

Performance can be tricky to analyse on boards that can play fast and loose with power management. Tiny margins don't matter a lot at the best of times but it's important to

remember that the Asus consumed some 30w less than the other boards with AB on. We're happy to give away a percent or two here or there for the sake of a significant power consumption reduction. Asus likely tunes its BIOS in order to protect its VRM from too much punishment. After all, this is a reliability themed board.

The \$379 the Asus TUF comes in towards the mid-lower end of the Z590 range. If you went for a true entry level Z590 board, we probably wouldn't feel comfortable pushing an 11900K with it. The Asus can and that adds a great deal of peace of mind. What does a gamer, as opposed to a PC enthusiast really need? It's got Wi-Fi 6, 2.5G LAN and support for the fastest PCIe 4.0 SSDs. Setting it and forgetting it, out of sight and mind is how a lot of users run their system. And that will suit this board. It's got the essentials, good bang for buck and it should be a safe and reliable option.

The Asus Z590 TUF is a good no frills, affordable Z590 option.
★★★★☆



\$649 | www.aorus.com

Gigabyte Z590 Aorus Master

Flagship features without the flagship pricing.

Gigabyte's Aorus Master boards usually impress us. They're unmistakably high-end boards, but they sit in a price range that hits a good balance of pricing and premium features without resorting to the extreme cost that burdens boards that include the kitchen sink.

If you're planning to run an overclocked 11900K, you need a board with a very strong VRM, and the Aorus delivers. With its 18 phase 90A design fed by dual 8-pin power connectors, it's about as good as it gets. We love the Aorus-finned heatsink design that prioritises function over form. The solid metal chunks on many boards may look good, but efficient cooling relies on surface area and with the way Rocket Lake can punish the VRM, Gigabyte's choice is the smart one. With Adaptive Boost on, the highest VRM temperature we saw was just 58 degrees, that's the best result of the test.

The board features a subtle design. Where once Aorus turned the RGB up to 11, the Z590 Master features just a couple of touches of RGB around the chipset heatsink and rear I/O. You get three M.2 slots all with heatsinks plus the now

common six SATA ports. The board includes three PCIe 16x slots, but somewhat unusually, no 1x slots. This shouldn't affect a lot of users but after you use the topmost one for a GPU, you're down to two slots, so take note if you use several expansion cards.

The Master's rear I/O includes almost everything you'd ever want with ten USB ports including a USB 3.2 Gen 2x2 Type-C port. Would a couple more be nice at this price point? That's a real nitpick. You get Wi-Fi 6E and – somewhat surprisingly at this price – Aquantia 10Gb LAN. Usually that's one of those features that's exclusive to the uber expensive flagship boards. Users of SSD-based NAS rejoice!

Motherboard audio is sometimes neglected. Not so in the case of the Z590 Aorus Master. It features the Realtek ALC1220-VB code with an ESS ES9118 Sabre DAC with WIMA and Nichicon capacitors. You'll have to drop more than a few dollars to get a better audio solution.

Our 11900K sample is genuinely cooling-limited and 5.2GHz is the best we've been able to get out of it even with an AVX offset. The Aorus easily

SPECS
LGA 1200 socket;
3x M.2; 6x SATA;
1x USB 3.2
Gen2x2, 6x USB
3.2 Gen 2, 8x USB
3.1 Gen 1, 4x USB
2.0; 1x DP; Intel
Wi-Fi 6E; Aquantia
10G LAN; Realtek
ALC 1220-VB 7.1
Channel HD Audio;
ATX Form Factor.

reproduced this result with DDR4-3600 at C14 with the memory running in 1:1 mode. Performance wise the boards are all mostly within a fraction of each other, however the Gigabyte really impressed us with its SSD performance, easily leading the other boards. In fact, it's the first board that beat our AMD system's results with a fast Samsung 980 Pro. Gigabyte clearly spent time getting its PCIe 4.0 performance up to scratch.

We really like the Z590 Aorus Master. It's got a mega VRM, 10G Lan and Wi-Fi 6E and good connectivity. Add to that class leading SSD performance and a decent price and it deserves a spot on your shortlist of upper mid-range contenders. We'd like to see a PCIe 1x slot or two but at this price we can hardly complain. The likes of the Asrock Taichi, MSI Ace and Asus Hero have a difficult time matching the value on offer from the Z590 Aorus Master.

If you're planning to overclock an 11900K and want a feature loaded board at a decent price, look right here.

★★★★★



\$549 | www.msi.com

MSI MPG Z590 Gaming Carbon Wi-Fi

A balanced all-rounder.

The MSI MPG Gaming Carbon sits right in the middle of its Z590 product stack, below the expensive flagship MEG boards and above the affordable MAG range. Its upper mid-range positioning aims to strike a nice balance of affordability while including the important features that a typical gamer really needs.

The Gaming Carbon reminds us of an 80s boom box with its spectrum analyser theme. It's a bit of a take it or leave it kind of design. We like the way that MSI has incorporated the design into the heatsink assembly, which has the dual benefit of adding surface area, which is needed for a hungrier 11th Gen CPU like the 11900K.

Storage functionality is atypical for a Z590 board three M.2 slots, the topmost of which runs at PCIe 4.0. They are joined by six SATA ports.

A real strength of the Z590 Gaming Carbon is its 16-phase VRM with 75a power stages. It can't quite match the VRM of the Aorus Master but an overclocked 11900K will run into cooling limitations before the board itself is stressed. It's a bit sad that boards need

SPECS
LGA 1200 socket;
3x M.2; 6x SATA;
1x USB 3.2
Gen2x2, 4x USB
3.2 Gen 2, 4x USB
3.1 Gen 1, 8x USB
2.0; 1x HDMI, 1x
DP; Intel Wi-Fi 6E;
Intel I225V 2.5G
LAN; Realtek ALC
4080 7.1 Channel
HD Audio; ATX
Form Factor.

power delivery systems like the ones we're seeing on Z590 boards. Efficiency is not Rocket Lake's strong point to put it mildly.

The rear I/O is very impressive. You get a total of ten USB ports consisting of a Type-C USB 3.2 Gen2x2 port, three USB 3.2 Gen 2 ports, two USB 3.2 Gen 1 ports and four USB 2.0 ports. The new Realtek ALC 4080 codec powers the standard set of audio ports, which includes S/PDIF. The MSI ticks the right boxes with regards to it's networking, thanks to Intel I225-V 2.5 GbE and AX210 Wi-Fi 6E controllers. DP and HDMI ports are useful should you need to use the Xe graphics on a Rocket Lake CPU.

The performance of the MSI was interesting. It proved to be very strong at multi-threading but it pays a price to do it. The MSI was the most power-hungry of the boards; in fact it can consume over 300w under an adaptive boost AVX load. If you plan to run this board, you'll need to make sure you have top shelf cooling unless you hop into the BIOS to moderate the power settings. These settings are easy to find thanks to MSI's

long-running and mature BIOS design.

The MSI, with its strong VRM and heatsink assembly, didn't break a sweat under a heavy Adaptive Boost load. Although it was one of the warmer boards we've tested, at 69c the temperatures aren't a cause for any concern. Unless you win the silicon lottery, at 5.2GHz with all cores loaded the power consumption can jump to over 350w! Yes you read it right. The MSI handled it with ease.

The MSI Z590 Gaming Carbon really appeals thanks to its balance of relative affordability and quality features, particularly its strong VRM, networking and I/O. It's at the right spot on the price/features curve. If you added 10G LAN, a Thunderbolt controller and a water block and it would be double the price. The MSI hits just the right balance.

The MSI strikes a good balance of affordability and features by omitting bells and whistles to keep the cost down.

★★★★☆

AMD Radeon RX 6700 XT Benchmarks

Best result

	X264 v5.0 Video Encoding	Cinebench 20		Blender 2.79 BMW Render	7Zip	POV-Ray 3.7.1	Handbrake Video Encoding
	Pass 2 Avg FPS	Multi thread Score	Single thread Score	Time (secs) Lower is better	Million Instruction per second	Ray Tracing - Pixels Per Second	4K 10-Bit HEVC to 1080p FPS
Asus TUF Gaming Z590-Plus Wifi	44.57	5,726	639	206.3	56,747	6,094*	71.6
Asus TUF Gaming Z590-Plus Wifi AB On	50.88	6,168	641**	183.9	59,030	6,621	73.5
MSI Z590 Gaming Carbon WiFi	45.20	5,835*	628	190.3*	57,684	6,032	73.8*
MSI Z590 Gaming Carbon WiFi AB On	51.20**	6,289**	628	180.4**	59,584	6,689	76.6**
Asrock Z590 PG Velocita	45.28*	5,819	641*	205.1	57,978*	6,029	72.6
Asrock Z590 PG Velocita AB On	50.83	6,253	639	183.9	59,997**	6,678	73.1
Gigabyte Z590 Aorus Master	44.37	5,805	635	204.8	56,597	6,014	71.9
Gigabyte Z590 Aorus Master AB On	50.87	6,278	640	182.3	59,466	6,693**	73.7

	CPU-Z		3DMark TimeSpy Extreme		3DMark TimeSpy		Middle Earth Shadow Of War
	Single Thread Score	Multi Thread Score	Overall score	CPU Score	Overall score	CPU Score	1080p, Lowest Preset, Avg FPS
Asus TUF Gaming Z590-Plus Wifi	694	6,643	8,178	5,737	16,294	11,700	241
Asus TUF Gaming Z590-Plus Wifi AB On	713**	7,042	8,222	5,948	16,361	12,039	253
MSI Z590 Gaming Carbon WiFi	699	6,649*	8,183	5,785	16,309	12,017*	244*
MSI Z590 Gaming Carbon WiFi AB On	701	7,054**	8,264	6,061	16,450	12,557**	261**
Asrock Z590 PG Velocita	704*	6,642	8,220*	5,807*	16,356	11,862	240
Asrock Z590 PG Velocita AB On	700	7,041	8,324**	6,088**	16,618**	12,325	258
Gigabyte Z590 Aorus Master	698	6,637	8,159	5,733	16,358*	11,693	241
Gigabyte Z590 Aorus Master AB On	702	7,049	8,252	5,991	16,451	12,225	256

	Peak Power Consumption	VRM Temperature	Civilization VI			Metro: Exodus	
	Povray pack- age power hwinfo	10 minutes of CB R20	1080p, Ultra, DX12, Avg FPS	1080p, Ultra, DX12, Min FPS	1080p, Ultra, DX12, AI Turn Time	1080p, Ultra, DX12, Avg FPS	1080p, Ultra, DX12, Min FPS
Asus TUF Gaming Z590-Plus Wifi	200*		241	172	7.83	122.8	60.2
Asus TUF Gaming Z590-Plus Wifi AB On	273**	60	245	175	7.73	123.6	60
MSI Z590 Gaming Carbon WiFi	216		242*	173*	7.73*	124.0*	62.4
MSI Z590 Gaming Carbon WiFi AB On	307	69	247**	175	7.72**	124.7	62.5
Asrock Z590 PG Velocita	202		238	173*	7.87	122.9	61.8
Asrock Z590 PG Velocita AB On	304	69	250	177**	7.73	124.3	61.7
Gigabyte Z590 Aorus Master	207		239	172	7.82	122.9	62.5*
Gigabyte Z590 Aorus Master AB On	302	58**	247**	177**	7.77	124.9**	62.7**

	Ghost Recon: Breakpoint	Far Cry New Dawn		AS SSD			
	1080p, Low, Avg FPS	4K Ultra Pre- set Avg FPS	4K Ultra Pre- set Min FPS	Sequential Read MB/s	Sequential Write MB/s	4K Read MB/s	4K Write MB/s
Asus TUF Gaming Z590-Plus Wifi	187	99	84	5625	3947	79.4	180.0
Asus TUF Gaming Z590-Plus Wifi AB On	187	99	84	5696**	3964	80.9	188.7
MSI Z590 Gaming Carbon WiFi	190	99	84	5383	3932	81.1	194.0
MSI Z590 Gaming Carbon WiFi AB On	192	100**	85**	5496	3990**	81.1	193.2
Asrock Z590 PG Velocita	187	99	84	5426	3870	66.4	185.2
Asrock Z590 PG Velocita AB On	193**	100**	84	5577	3883	66.8	186.4
Gigabyte Z590 Aorus Master	191*	100*	85*	5637*	3969*	86.4*	213.6*
Gigabyte Z590 Aorus Master AB On	190	100**	84	5649	3943	86.2**	214.4**

Test Setup CPU Intel Core i9-11900K, GPU MSI RTX 3080 Gaming X Trio, RAM 16GB Teamgroup T-Force DDR4-3600 14-15-15-35, Storage 2TB Adata S70 & 500GB Samsung 980 Pro, Case Thermaltake Core P8, Cooling Nzxt X73 360mm AIO, Power Supply Corsair AX1000, Operating system Windows 10 Pro x64 20H2
 * Default settings **Adaptive Boost enabled, power restrictions removed

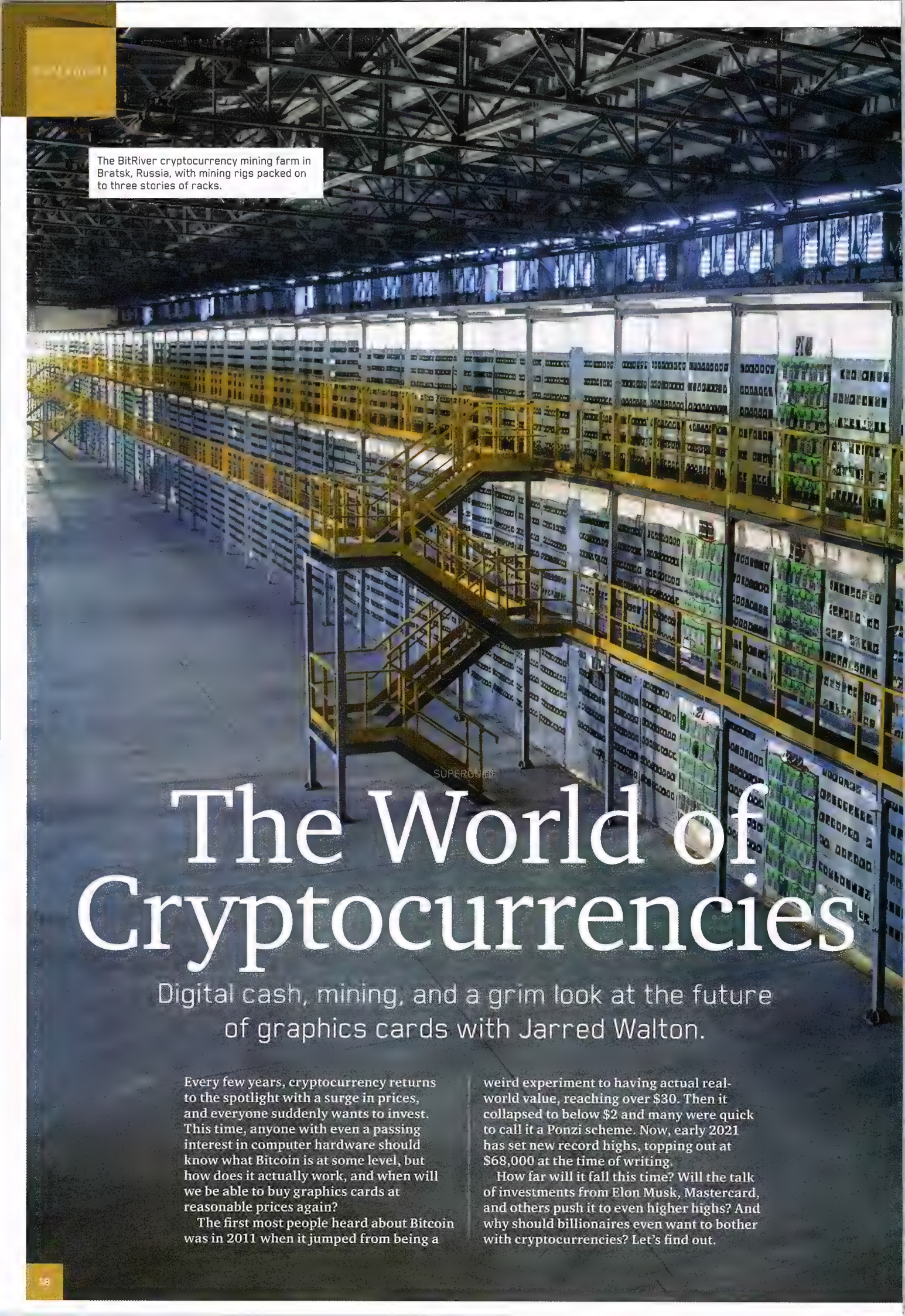
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The BitRiver cryptocurrency mining farm in Bratsk, Russia, with mining rigs packed on to three stories of racks.

The World of Cryptocurrencies

Digital cash, mining, and a grim look at the future of graphics cards with Jarred Walton.

Every few years, cryptocurrency returns to the spotlight with a surge in prices, and everyone suddenly wants to invest. This time, anyone with even a passing interest in computer hardware should know what Bitcoin is at some level, but how does it actually work, and when will we be able to buy graphics cards at reasonable prices again?

The first most people heard about Bitcoin was in 2011 when it jumped from being a

weird experiment to having actual real-world value, reaching over \$30. Then it collapsed to below \$2 and many were quick to call it a Ponzi scheme. Now, early 2021 has set new record highs, topping out at \$68,000 at the time of writing.

How far will it fall this time? Will the talk of investments from Elon Musk, Mastercard, and others push it to even higher highs? And why should billionaires even want to bother with cryptocurrencies? Let's find out.



Meet the blockchain

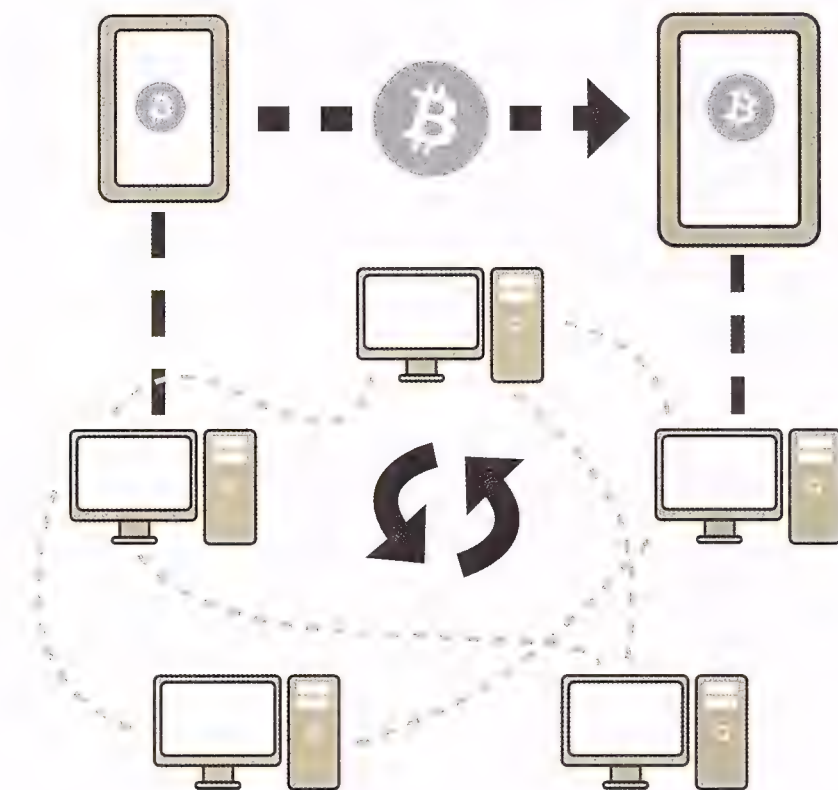
The starting point for Bitcoin and other cryptocurrencies is the blockchain. It's become a buzzword, but the short description is pretty drab. The blockchain contains an open ledger of all transactions that have ever taken place on a given cryptocurrency network. Did you send money to Uncle Theo, paying him for a graphics card? It's in the blockchain, for everyone to see. So, when your friend comes by claiming you never paid him back for the concert tickets, or the fast-food stop, or whatever, you can find incontrovertible proof – one way or the other.

That might sound interesting, but it probably sounds alarming, too. Why would you want everyone to be able to check on what amounts to your digital bank account? That's where the second part of the blockchain comes into play: All transactions are at least somewhat anonymous. Unless you publicly list your Bitcoin wallet address – and it's trivial to create more addresses, so you can have more than one – determining what money belongs to whom is difficult. It's not impossible, especially with enough time, effort, and use of a specific wallet, but there are ways to obfuscate your transactions and keep them veiled from prying eyes.

The more important aspect of the blockchain isn't just that it keeps a record of all transactions. The critical factor is that it's backed by strong cryptography – SHA256, in the case of Bitcoin, and dozens of other cryptographic algorithms for other coins. A lot of complex math goes into the creation of a good cryptographic algorithm, with the end goal being that the only way to crack it would be brute force. SHA256 has a 256-bit cypher length, so breaking the encryption for a single message would involve finding the one number out of a 2256 number space that's correct.

If that doesn't seem like a big deal, let's put it differently: 2256 is the same as 1.158×10^{77} , or in other words, it's a 1 followed by 77 zeroes. Our solar system has roughly 1.2×10^{56} atoms, the Milky Way galaxy has approximately 2.4×10^{67} atoms, and depending on whose math you want to use, the entire universe has anywhere from 1078–1082 atoms. That means a 256-bit number space is large enough that you can easily assign a unique number to every atom in the galaxy, with room to spare.

We're simplifying quite a bit, but the main point is that cracking the cryptography behind Bitcoin would be extremely difficult, and other coins use even stronger cryptography. Bitcoin and other cryptocurrencies also use cryptography for the unique user wallet addresses. In the case of Bitcoin, there are currently a potential 2160 addresses, or



The blockchain is essentially an open ledger keeping track of every cryptocurrency transaction, run over a huge distributed network.

around a quindecillion. No, we didn't just make that word up. That's a one with 48 zeroes after it. Or if you prefer, it's $1 \text{ trillion} \times 1 \text{ trillion} \times 1 \text{ trillion} \times 1 \text{ trillion}$. We're not likely to run out of wallet addresses anytime soon.

All of this cryptography plays a pivotal role in cryptocurrencies, as you might guess considering the name. They're "currencies" – perhaps digital commodities would be a better name, but that ship has sailed – backed by cryptography. And when we say cryptography, what we mean is complex math, the sort of thing to make even your calculus teacher squinch up their face. So-called "fiat" currencies, such as the US dollar, are backed by trust in the government and banking institutions. Bitcoin and Ethereum are backed by our trust in math. Actually, they're backed by math plus all of the people willing to participate in securing the cryptocurrency network, which brings us to the next topic.

Securing the blockchain

We've talked about cryptography, but what exactly makes this whole blockchain thing secure? Cryptocurrencies run as a large distributed network of computing resources, with the various nodes communicating with each other. Every time someone wants to move coins – or really, a portion of a coin, with most cryptocurrencies able to deal with amounts to eight decimal places – they send a transaction out on to the network

and it becomes available for inclusion in the next block. Each block encapsulates all of the transactions since the previous block into one chunk, creates a digital hash signature of the block, and the entire thing gets submitted as a new addition to the blockchain.

Here's where things get interesting. You can't just add a new block to the network any time you want. That block needs to satisfy certain requirements. In short, you need to find a solution to a mathematical function defined by the coin algorithm. The function uses the results of the previous block as input, going back in a chain to the original genesis block. This means no one can get a head start by trying to solve for future blocks until the current block has been "solved." The algorithms are also designed such that the solutions are effectively random, selected from the entire number space for the cryptography key. There can be a huge number of acceptable solutions, and your hardware just needs to find one of these.

When a system does find a solution, it gets to pick which transactions get included in that block (ideally, all of them, but more on that in a moment), wraps them all up with a tidy bow, calculates a digital signature, and submits that to the network. Other nodes on the network can then verify the solution and accept or reject it. Each potential solution has a timestamp, and the network has various criteria to help determine which block was found first. Eventually, the network reaches a consensus among enough nodes

Safe GPU mining settings

Assuming you're interested in trying out cryptocurrency mining, there's a lot of conflicting advice on how to go about tuning for optimal performance. Many tutorials throw caution to the wind and look to maximise hash rates, with little heed to the differences in individual graphics cards. It's a fast track to dead hardware if you're not careful. While it's true that AMD and Nvidia graphics cards tend to be tuned somewhat conservatively, the intent is for the card to handle hours of gaming, every day, for several years. 24/7 cryptocurrency mining is a completely different use case.

There's a reason Nvidia's data center GPUs are usually clocked lower than consumer GeForce parts, with very different cooling configurations. Supercomputers use high-speed fans that push a lot of air through the coolers, and the fans are designed to be hot-swappable. The cards are designed for 24/7 high utilisation, which means thermal pads and other elements are also built to those specifications. Even someone playing games eight hours a day, every day, won't come close to punishing a card like mining will. Keep that in mind.

Also remember that what works well on one GPU, or even one particular card using a specific GPU, may not work everywhere. The silicon lottery is real, parts are binned and tested to meet certain criteria, and some have more headroom than others. Redlining a graphics card to improve hash rates might result in short-term gains, but it's also a quick way to burn out fans, VRMs, memory chips, or even the GPU. Start slow, check how your card is doing on temperatures and fan speeds, and don't worry about chasing down every last hash.

To check your temperatures and fan speeds, we recommend using HWInfo64 (image right). The latest version shows maximum GDDR6X temps on the RTX 3080 and 3090, as well as GDDR6 temperatures on most AMD RX 5000 and RX 6000 cards (so far, GDDR6 thermals on RTX 20-series and lower tier RTX 30-series GPUs aren't available). The specific card and fan design play a role, and consumer graphics card fans are not designed to run at a constant 80-100 percent fan speed, all day, every day. Many cards actually limit the maximum fan speed to around 50 percent, and won't go above that unless things get really bad – like super-hot GDDR6X temperatures. Consumer cards also tend to prioritise lower noise levels and higher temperatures, which is counterproductive to 24/7 mining.

If you want a reasonable estimate of where a card should run its fans, turn off any overclock and launch a demanding game such as Metro Exodus at 1440p ultra settings, and just let it run for 15-20 minutes, then check temperatures, fan speeds, clocks, and so on. The maximum fan speed you see is what the manufacturer thinks should allow the card to last three-plus years. Go anywhere above that and you're more likely to have fans or other components fail.

HWINFO64 v7.00-4400 Sensor Status

Sensor	Current	Minimum	Maximum	Average
GPU [#0]: AMD Radeon RX 6800 XT				
GPU Temperature	58.0 °C	58.0 °C	60.0 °C	58.4 °C
GPU Memory Junction Temperature	58.0 °C	58.0 °C	60.0 °C	58.6 °C
GPU VR VDDC Temperature	56.3 °C	55.9 °C	58.0 °C	56.8 °C
GPU Hot Spot Temperature	60.0 °C	60.0 °C	62.0 °C	60.7 °C
GPU VR SoC Temperature	54.0 °C	54.0 °C	55.0 °C	54.4 °C
GPU VR VDDIO Temperature	56.4 °C	56.0 °C	58.0 °C	57.0 °C
GPU VR VDDCI Temperature	54.0 °C	53.7 °C	55.5 °C	54.5 °C
GPU Core Voltage (VDDCR_GFX)	0.584 V	0.154 V	0.844 V	0.454 V
GPU Memory Voltage (VDDIO)	1.250 V	1.250 V	1.310 V	1.253 V
GPU SoC Voltage (VDDCR_SOC)	0.944 V	0.934 V	0.950 V	0.942 V
GPU Memory Voltage (VDDCI_MEM)	0.675 V	0.675 V	0.762 V	0.679 V
GPU Fan	0 RPM	0 RPM	0 RPM	0 RPM
GPU Core Current (VDDCR_GFX)	7.779 A	2.042 A	12.142 A	6.207 A
GPU Memory Current (VDDIO)	1.465 A	0.527 A	4.384 A	1.364 A
GPU SoC Current (VDDCR_SOC)	2.843 A	1.518 A	4.945 A	2.390 A
GPU Memory Current (VDDCI_MEM)	0.001 A	0.000 A	5.289 A	0.212 A
GPU Core TDC Limit	300.000 A	300.000 A	300.000 A	300.000 A
GPU SOC TDC Limit	55.000 A	55.000 A	55.000 A	55.000 A
GPU Core Power (VDDCR_GFX)	6.661 W	1.728 W	10.480 W	5.305 W
GPU Memory Power (VDDIO)	1.832 W	0.659 W	5.858 W	1.723 W
GPU SoC Power (VDDCR_SOC)	2.693 W	1.426 W	4.682 W	2.262 W
GPU Memory Power (VDDCI_MEM)	0.001 W	0.000 W	4.416 W	0.174 W
GPU ASIC Power	5.000 W	5.000 W	32.000 W	12.638 W
TGP Power	16.086 W	8.713 W	30.336 W	14.363 W
GPU PPT Limit	255.000 W	255.000 W	255.000 W	255.000 W
GPU PPT	16.674 W	8.999 W	29.697 W	14.323 W
GPU Clock	0.0 MHz	0.0 MHz	68.0 MHz	6.5 MHz
GPU Clock (Effective)	6.6 MHz	5.0 MHz	131.1 MHz	22.9 MHz
GPU Memory Clock	8.0 MHz	6.0 MHz	906.0 MHz	104.4 MHz

For temperatures, lower is better, at least up to a point (i.e. not freezing). For long-term mining, we'd try to keep GPU temperatures below 70 C, but that may not even be the critical factor. Keeping VRM (Voltage Regulator Modules) temperatures below 85 C is also desirable, and we definitely wouldn't run with memory temperatures over 100 C and expect a card to remain viable. The RTX 3080 and 3090 are the worst culprits, with GDDR6X often settling in at 106-110 C, but better cards – or ones where you've replaced the default thermal pads with something better – can keep GDDR6X mining temperatures under 90 C.

Depending on your GPU, tuning performance can often dramatically cut power requirements without impacting hash rates, and lower power generally means lower temperatures as well. Ethereum mining prefers memory bandwidth over raw computational power, so turning down GPU clocks and power limits while overclocking the memory usually leads to better performance. Undervolting the GPU core can also help reduce power and heat, particularly on certain AMD GPUs. Search the web for details on your specific GPU, but again be conservative, and don't jump straight to maximum performance settings. If your particular card ends up 10-15 percent slower on hash rates than you see others reporting, but your temperatures and power use are lower, the card will likely last longer.



From left to right: Ethereum, launched in 2015; Bitcoin Cash, which split from Bitcoin in 2017; Litecoin, launched in 2011, making it an old-timer; Dash, which is similar to Bitcoin, but uses a two-tier structure of miners and masternodes; Bytecoin – not to be confused with Bitcoin.

What are ASICs?

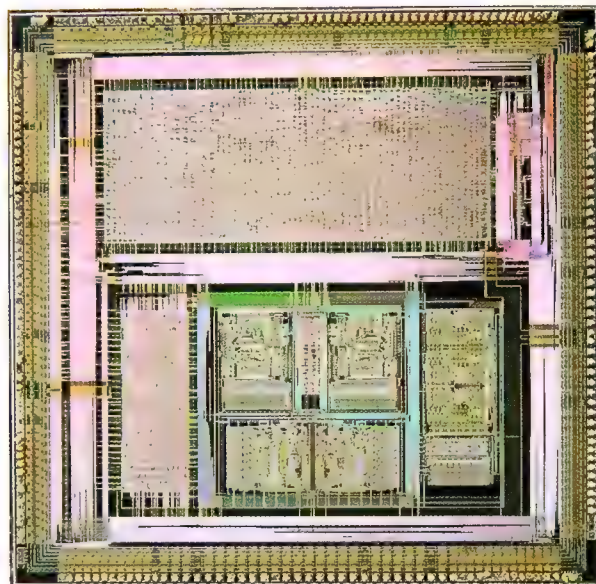
We've focused most of our efforts on the description of mining with GPUs, but originally Bitcoin was designed to be mined using CPUs. It just so happened that with GPUs becoming increasingly programmable, software developers figured out they could get 10, 100, or maybe even 1,000 times the performance of a CPU by doing the calculations on a GPU.

But GPUs aren't optimised for doing just cryptographic hashing calculations – there's a whole bunch of extra stuff for textures, 3D graphics, anti-aliasing, ray tracing, and so on. What if you stripped out all of those unnecessary capabilities and focused on creating a chip that was only good at one thing: cryptographic hashing? It would be faster than a GPU, potentially mining even more Bitcoins! Not surprisingly, lots of others felt like this was a good idea as well.

The result is called an ASIC, Application Specific Integrated Circuit. Technically, a GPU is a type of ASIC, it just happens to be focused on graphics work, while a CPU is a general-purpose ASIC for x86 architectures, or ARM, or whatever. Bitcoin ASICs focus on boosting SHA256 hashing rates as high as possible. Current ASICs can perform somewhere around 1,000 times more hashes per second than even the best GPUs, using a similar amount of power.

There was also an intermediate step between GPUs and ASICs: the FPGA (Field Programmable Gate Array). FPGAs are reconfigurable silicon that can be updated to run different algorithms. There was a brief span of time when FPGAs were used for Bitcoin mining, offering about 10 times the performance of a GPU in the same power envelope, but it wasn't long before fully custom ASICs replaced FPGAs for most hashing algorithms.

Using an ASIC for cryptocurrency mining is a lot more productive than using a GPU or CPU.



“What if you stripped out all of those unnecessary capabilities and focused on creating a chip that was only good at one thing: cryptographic hashing?”

that things move on, so if two different people (machines) find different solutions at the same time, only one ends up as the accepted “winner.”

What is cryptocurrency mining?

Coin mining tends to make a lot of gamers and PC enthusiasts angry – angry or rich, depending on when they started doing it. When you hear talk of GPU shortages and mining farms, it stems from the above cryptography and securing of the networks. At their core, most cryptocurrencies depend on people joining the coin network to provide security. What they're actually doing is donating hardware cycles to run the cryptographic algorithms to find the block solutions that keep everything flowing. But why would anyone want to do this? Answer: They get rewarded.

As an incentive to donate your hardware cycles to a particular network, whenever a new block solution is found and accepted, the algorithm provides a block reward. For Bitcoin, this started at 50 BTC per block, while Ethereum provided 5 ETH per block. But there's more to it than just finding a block and getting a reward.

To constrain supply, most coins also reduce the block rewards over time. Bitcoin's algorithm cuts the reward in half

every 210,000 blocks – we'll get to the why of that figure in a moment. Dogecoin had a random reward of 0–1,000,000 DOGE per block at first, cutting the maximum reward in half every 100,000 blocks, but switched to a static block reward of 10,000 DOGE after block 600,000. Ethereum took a different approach, with no hard limit and no set halving algorithm, but a design that planned for regular network updates. The block reward for Ethereum was set to 3 ETH in late 2017, and changed again to 2 ETH in early 2019.

If you're wondering about the discrepancy in block rewards, it's important to note that each coin algorithm also designates a different target rate for new blocks. Bitcoin aims for an average of 10 minutes per block – it's a long time, but it was the first cryptocurrency and once it gained popularity, it was increasingly difficult to change the underlying algorithm. For better or worse, Bitcoin has stuck with that 10-minute block time. Litecoin has a lot of similarities to Bitcoin, except it defined a block target time of 2.5 minutes, with the reward cut in half every 840,000 blocks.

Combined with the block reward halving structure, there's a limit to the total number of Bitcoins that will ever be

created: 21 million, with half of them generated in the first 210,000 blocks, half of a half in the next 210,000, and so on. Technically, we'll never quite get there, but we'll get increasingly closer to the limit. Litecoin quadrupled the total number of coins it would produce to 84 million. Other coins have sometimes wildly differing schemes, but generally, scarcity is involved – rare things are worth more.

The critical factor with all coins is that the algorithms are designed to adjust the difficulty of finding a solution over time. The more hardware running the algorithms, the faster blocks would be found if the difficulty were static. The solution space ends up being adjusted to fit within certain parameters, which in turn resets the typical block time. This means that, for a given set of hardware, the more people running the mining algorithm, the fewer coins each one will get through mining over time. This has the side effect of creating an arms race to get more hardware up and running as quickly as possible, leading to ever-increasing mining farm sizes. That in turn leads to GPU shortages – or ASIC shortages (see “What are ASICs?” above).

Rewards aren't limited to just the block reward, though. Also included are all the fees for transactions included in the block.



These examples are probably a bit more glamorous than your average mining setup, but this is what it could look like.

Early on, these fees tend to be very limited, but lately, as an example, the transaction fee rewards on Ethereum blocks are pretty close to matching the 2 ETH block reward, meaning each block is actually worth 4 ETH. The idea is that by the time the static block rewards approach zero, they've been superseded by the transaction fee rewards.

The need for speed

Ultimately, coin mining ends up being a question of speed and efficiency. This generally gets measured in the hash rate, expressed using SI prefixes and H/s (hashes per second). The complexity of the hashing algorithms varies greatly, which means there's no universal hash rate for any set of hardware. Some algorithms are also designed to require more memory (such as Ethereum), which can further limit the types of hardware that can effectively run the hashing calculations.

The fastest GPU right now, RTX 3090, has a hash rate of around 120MH/s (megahashes per second) for the Ethereum algorithm, called Ethash (an upgraded version of Dagger-Hashimoto, but we digress). The same GPU can do around 1,000MH/s, or 10GH/s, with Bitcoin's SHA256 algorithm. Modern SHA256 ASICs, meanwhile, can do

roughly 25TH/s.

Speed is important, but the amount of power used also factors into the picture. If some piece of hardware is 10 times faster but requires 10 times as much power, it's not really a net win. Tuning your hardware for optimal performance is another important task. Out of the box, for example, an RTX 3080 might use its full 320W of power to get around 85MH/s for Ethereum. Drop the GPU clock speed and limit the power while overclocking the memory and it's possible to get 95MH/s while only using 220W of power.

Lowering the power has the added benefit of lowering GPU temperatures, which means running fans slower and hopefully getting your GPU to last a lot longer. However, Nvidia's RTX 3080 and 3090 come with GDDR6X memory that can be more of a problem when it comes to thermals than the GPU cores.

The reference 3080 and 3090 Founders Edition cards both hit 110 C on their GDDR6X memory at stock settings – that's not something we'd feel comfortable running as a long-term mining solution.

Replacing the thermal pads, adding fans, and other mods can improve the situation, and we advise anyone doing mining with a GDDR6X card to use HWinfo64 to check memory temperatures.

How to mine cryptocurrencies

The basics of mining cryptocurrencies haven't changed too much over the years. You need the appropriate hardware – GPU, ASIC, or even CPU – and the requisite software. There are a few different software packages available, many of which can be quite complex to configure and get running optimally. If you're looking for an easier path to dipping your toe into the mining waters, consider using NiceHash (see box over the page).

One thing we don't recommend is trying to mine "solo." That may have been possible in the early days of Bitcoin, or you could give it a shot if you build your own large-scale mining farm (please don't do that!), but these days you'll have far more success using a mining pool. That means picking a pool in the first place, and you'll want to research that via the internet (for example, "best ethereum pool" should give you some reasonable options). Then you'll need to set up an account, download the appropriate mining software, and configure the launch settings as appropriate.

You'll want to pay close attention to any pool mining fees. These typically range from 0–3 percent, sometimes more, but plenty of good options usually land at the 1 percent value. It costs money to run the



The Bitcoin network uses 3,000 times as much energy as the world's fastest supercomputer, the Japanese Fugaku.

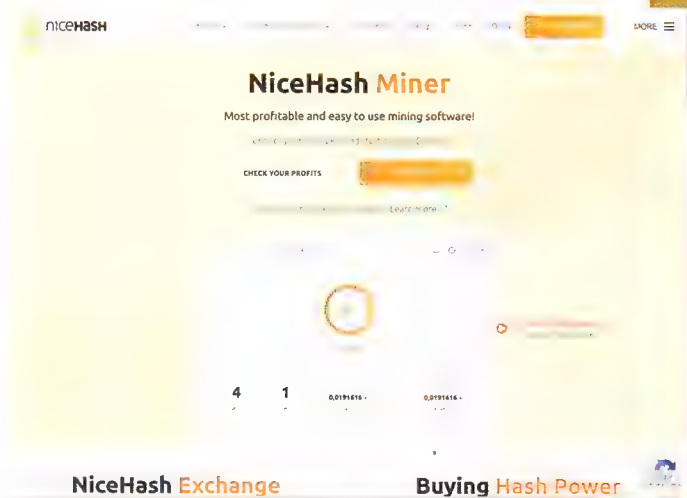
© STR / JUI PRESS / AFP / Japan OUT (Photo by STR / JUI PRESS / AFP via Getty Images, nicehash)

Mining BTC with a GPU: NiceHash

Arguably the easiest way to get started at mining cryptocurrencies is with NiceHash. We've noted that it's no longer profitable to mine Bitcoin directly using a GPU, because ASICs are so much faster and more efficient. That doesn't mean you can't get BTC from a GPU, however. NiceHash launched in 2014 and greatly lowered the barrier to entry for mining. It gets rid of the worry about what coin(s) to mine and is extremely easy to get running. You lease your PC's hashing power to other users, who get to choose what to mine, and you get paid in Bitcoin. NiceHash takes a small cut of the potential profits, and your PC can be up and mining in minutes.

The company's custom NiceHashMiner software benchmarks your hardware using various common hashing algorithms, and offers plenty of configuration options. NiceHashMiner then chooses whatever hashing algorithm currently pays the best rates, based on what people are willing to pay to lease your hardware. Sometimes a new coin launches, or someone wants to dedicate a lot of mining power at a specific coin, and they pay more to do so. Instead of mining Ethereum 24/7, your hardware will occasionally run some other algorithm, and it's all managed by the software. The software also has auto-update functionality to keep you on top of the latest developments.

There are other ways to mine with NiceHash, such as its QuickMiner software, which aims to make the process even easier. Alternatively, there's a custom NiceHash OS Linux-based install you can run in place of Windows. Performance



and efficiency are potentially higher, and for dedicated 24/7 mining, it's supposed to be the best option.

So, next time you hear someone say, "You can't mine Bitcoin with GPUs anymore," you can set them straight. While it's true that directly mining BTC with a GPU isn't a good idea, services such as NiceHash provide a convenient workaround. Alternately, just mine Ethereum or whatever on your own, and then trade that for Bitcoin.

"The company's custom NiceHashMiner software benchmarks your hardware using various common hashing algorithms, and offers plenty of configuration options. NiceHashMiner then chooses whatever hashing algorithm currently pays the best rates."

servers and infrastructure for a mining pool, and the fees go to support that (and make the pool owners a profit). Any “free” pools may end up being either unreliable, or with lower payouts that negate the benefit of not paying a fee.

One really important warning: Do not use the same password on any sites related to cryptocurrency mining. Seriously, just don’t – and don’t ask how we know this, please. Using a unique password on every site isn’t just best security practice, it’s a way to keep yourself from being robbed by potentially unscrupulous site owners.

Warning: high power

We’ve said a lot about the hows and whats of cryptocurrencies, but there’s one final item to address, and it’s a big one. While there are arguably worse ways to earn money than cryptocurrency mining, there are also a lot of better ways – ways that don’t carry nearly the volatility and risk of coin mining. Procuring all of the necessary mining hardware can take time and a lot of money, which makes it difficult for PC enthusiasts to upgrade their PCs. Hardware can wear out sooner than you expect. But the bigger issue, by far, is that mining puts a ton of computing power to the task of securing the blockchain.

Best case, using the most efficient hardware, the Ethereum network would currently use about 1 billion watts of power, and Bitcoin would use 5.5 billion watts. Unfortunately, it’s actually a lot more in both cases, because a large chunk of the hashing isn’t done using the most

efficient hardware. Online estimates peg the power use of the Ethereum network at around 21TWh per year, and 45kWh per transaction. Put another way, Ethereum hashing uses 60GWh every day, which costs slightly less than \$8 million. That works out to \$9.00 in power costs (using \$0.20 per kWh) just to send Ethereum from one wallet to another.

Bitcoin is even worse. The network currently uses an estimated 78TWh per year, with a cost for a single transaction of around 690kWh. That’s about as much power as a typical household uses in 24 days! That means Bitcoin uses \$10 billion per year just keeping the blockchain secure. That figure continues to grow, and while Bitcoin and Ethereum are the two largest cryptocurrencies, there are dozens of others that together require another large chunk of power.

Looking at the costs and power going into these networks, it’s difficult to remain optimistic about the long-term potential. We’re strip-mining digital coins, and that’s unsustainable. That’s part of the cyclic nature of Bitcoin, where it finally reaches a level that can’t be sustained, companies and people stop investing in it, and there’s a massive correction. A few years later, enough people have forgotten the last time this all happened that we see a repeat. There are other proposed alternatives to current reward schemes, such as proof-of-stake instead of proof-of-work, but they have their own drawbacks.

Imagine if all of the effort being put into cryptocurrency mining was instead put into research. While Bitcoin’s SHA256 hashing isn’t useful for many other tasks,

the most powerful supercomputer in the world – Japan’s Fugaku – has a peak power consumption of around 30MW. That’s a modest city’s worth of power, and yet the Bitcoin network uses roughly 3,000 times as much energy. What could scientists do with another 3,000 of the fastest supercomputers? We don’t know, but we’d love to find out. The money that’s pouring into cryptocurrencies could be put to far better uses.

These drawbacks won’t stop people from mining, though, at least not without help. Governments have started to crack down on mining farms, however – China’s Inner Mongolia recently issued a ban on cryptocurrency mining. Other areas of the world may follow suit. Regulation seems inevitable, and for something that’s supposed to free people from the oppression of the banking system, it’s difficult to get past the fact that every coin eventually derives its worth from how much it is worth in dollars, pounds, yen, and so on.

If you still want to give mining a shot, particularly if you already have a modest PC and you live in an area where power isn’t too expensive, or the power grid isn’t already having severe issues, we won’t object too much. But please don’t bet the farm or your retirement on PC hardware and upgrades solely used in pursuit of mining. There’s a real likelihood of chasing diminishing profits, potentially for years. You have to keep on mining in the hope of striking it rich with a future surge in cryptocurrency prices. We doubt we’ve heard the last of Bitcoin or Ethereum mining, but there’s a good chance anyone trying to start now has already missed the current wave. ■

All that power has to come from somewhere, and electricity generation isn't always the greenest of industries.



Can Bitcoin mining pay for a new gaming laptop?

Nick Ross set up a gaming laptop mining farm to find out.

Back in 2018, when Bitcoin exploded onto the public consciousness, we were in the process of writing a feature on whether you could subsidise the purchase of an epic gaming laptop by using it to mine Bitcoin. This was something of a necessity because then, as now, professional mining farms were buying up all the desktop graphics cards, meaning this was the only way for gamers (and creators) to get access to the latest GPUs. All our testing was done, we wrote the feature but right before we published the price crashed – destroying the economics that underpinned the feature.

Since that time, the early adopters, money launderers, criminals and geeks who made up much of the Bitcoin market have been replaced and/or augmented by traditional investors and government legislation. And although this article is tempting fate for another epic crash, the signs are that Bitcoin is here to stay and will continue to rise and fall and rise into the future.

Historical figures

Back in 2018 when Bitcoin settled at AUD\$10,000 and electricity cost 28c per kWh, we were looking at laptops with the following GPUs and daily figures:

- Nvidia GTX 1050 = 0.00007080 BTC = \$0.71
- Nvidia GTX 1060 = 0.00011500 BTC = \$1.2
- Nvidia GTX 1070 = 0.00015200 BTC = \$1.50
- Nvidia GTX 1080 = 0.00020000 BTC = \$2
- Nvidia 2x GTX 1080 Ti = 0.00049000 = \$5

Much has changed, but much hasn't. We've since experienced a halvening whereby mining rewards have halved. Furthermore, the cost of electricity has gone down; there are more renewables on the grid; new companies are offering innovative ways to purchase electricity; laptop power consumption and efficiency have increased and cooling technology has improved.

The price of Bitcoin has ballooned but the price of gaming laptops is similar.

Consequently, while you can still expect to earn roughly between \$1 to \$5 per day, that only translates to between 0.00002592 and 0.00007872 Bitcoin.

Ultimately, if you have faith that Bitcoin will be worth much more in the future and you're prepared not to sell it anytime soon, the likelihood of paying off at least some of your laptop increases. After all, that expensive SLI 1080 laptop in 2018, which was earning \$5 per day while costing more than \$3 in electricity, actually earned about \$40 worth of Bitcoin per day, in today's money. That could have covered the massive \$7,500 price tag in well under a year of part-time mining... with hindsight.

Today's figures

We tested more than a dozen laptops and recorded the following figures:

- Nvidia Quadro 5000 = 0.00002592 BTC = \$1.81
- Nvidia RTX 2070 Super = 0.00006434 BTC = \$4.50
- Nvidia RTX 2080 Super = 0.00005814 BTC = \$4.07
- Nvidia RTX 3060 = 0.00006144 BTC = \$4.30
- Nvidia GTX 3070 = 0.00007344 BTC = \$5.14
- Nvidia RTX 3080 = 0.00007966 = \$5.58

It's worth noting that the well-designed RTX 2070 laptop surpassed two "more-powerful" RTX 2080 laptops, due to it running more consistently at a higher temperature. It illustrates the point that GPU performance can vary considerably based upon each laptop's physical characteristics – especially the cooling technology and the tolerances built into that.

Note that for the following reviews we used Nicehash software for mining and used an average electricity price of 24c per Kilowatt hour.



Acer Predator Helios 300

Nvidia GeForce RTX 3060, 2.6GHz Core i7-10750H
\$2,499 | www.acer.com
34.46 MH/s | 0.00005952 BTC | 143 Watts

Acer's top-end Predator gaming laptop has particularly high mining potential thanks to its CoolBoost system that's based upon its 4th generation AeroBlade technology. This provides powerful, customisable fan control that can enhance overclocking speeds without fiddling with settings. But it does get rather loud when at full throttle and the noise fluctuates noticeably (and annoyingly) depending on temperature. Our model consumed 143W while managing a hash rate of 34.46, which meant that it earned \$3.34 per day with electricity factored in. The 15.6-inch (144Hz) screen and 2.5KG chassis mean it's relatively portable. Ultimately, it's good if you can put up with the noise.

The enhanced cooling system is great for mining but gets noisy under load.



Acer Nitro 5

Nvidia GeForce RTX 3060, 2.5GHz Core i5-10300H
\$1,799 | www.acer.com
34.00 MH/s | 0.00005904 BTC | 130 Watts

Acer's cheaper Nitro 5 range has less-beefy hardware than its Predator siblings, but it can match them where it counts: our unit had a gamer-friendly RTX 3060 and a 144Hz, 15.6-inch screen. The cooling proficiency is less powerful but it's still one of the best miners on show and it's significantly less noisy. It managed to remain under 68C when at full load compared to the Helios' 63C. The subsequent, lower (130W) power consumption and only slightly lower hashrate, means that it draws less electricity while delivering higher profitability: you can expect to earn \$3.38 per day with the Nitro 5.

A great value buy if you want a good gaming laptop that's also good at mining.



Alienware Area-51M R2

Nvidia GeForce RTX 2080 Super, 3.7GHz Core-i9-10900K
\$5,623 | www.dell.com/en-au
36.41 MH/s | 0.00005839 BTC | 220 Watts

Alienware's Area-51M R2 uses the term 'desktop replacement' and for good reason. This chunk doesn't just weigh in at almost 5KG, it has two (count'em) power supply bricks to lug around. In the past we've seen such set-ups when SLI graphics are included but the R2 uses a last-gen 2080 Super GPU. The good news is that the huge chassis allows for some serious (mainly CPU) overclocking and its cooling prowess means it can run cool and consistently (67C) at higher clock speeds, without making much noise. However, it's very expensive has high power consumption and its rivals are significantly smaller, cheaper and faster. Huge in size and huge in CPU performance but not good for mining.



Aorus 17G YC

Nvidia GeForce RTX 3080, 2.2GHz Core-i7-10870H
\$3,999 | www.gigabyte.com
44.21 MH/s | 0.00007082 BTC | 142 Watts

If you want a top-end, current-gen gaming laptop then the 17-inch Aorus ticks many boxes. In addition to the 300Hz screen is a mechanical keyboard – amazing for a 27mm-thick machine – that also sports individually lit RGB keys. Despite the 3080 GPU, the Windforce cooling technology kept it purring along relatively cool and quiet at just 74C. Total power draw was just 142W and yet it earned 7,082 Satoshis per day at a profitability of \$4.24. While it's not cheap, it's good value and if ever you needed an excuse to exceed your budget and cover the extra purchase cost using Bitcoin mining, this is it. If you want to subsidise a dream gaming notebook by mining, consider this.



Gigabyte Aero 15 OLED XC

Nvidia GeForce RTX 3070, 2.2GHz Core-i7-10870H

\$3,559 | www.gigabyte.com

44.93 MH/s | 0.00006816 BTC | 145 Watts

Gigabyte's Aero 15 OLED XC is something of a showstopper thanks to its 15.6-inch Samsung AMOLED 4K screen, which displays content that's incredibly bright, vibrant and sharp. Its colour accuracy is also tuned for professional designers. The RTX 3070 graphics will appeal to creators (and gamers who don't need a fast screen) and it offers high mining potential. All of this comes in an ultraportable, 2KG package with an eight-hour battery. The Windforce cooling can only do so much though and it did get noisy and hot (78C). Nonetheless, this is a heck of an ultraportable all-rounder that can earn \$3.94 per day.

Portable, powerful and with a stunning screen. Tempting for designers on the move.



Gigabyte Aero 17 HDR YC

Nvidia GeForce RTX 3080, 2.4GHz Core-i9-10980HK

\$5,399 | www.gigabyte.com

45.01 MH/s | 0.00007023 BTC | 138 Watts

This 17-inch powerhouse sports both a Core-i9 CPU and RTX 3080 graphics. Despite being a capable gaming machine its got an eye on designers first and foremost due to the professional Pantone calibrated screen which, like the Aero OLED, has a 60Hz refresh rate. At \$5,399 it's not particularly cheap but it can mine Bitcoin well with a hash rate of 45.01, which generated 7,023 Satoshis per day. Factoring in a modest power draw, that equates to a decent \$4.12 profitability per day. Meanwhile the larger chassis combined with the Windforce Infinity technology maintained a temperature of 75C with only a minor, consistent whine.

Big, powerful and expensive. Better for designers who need grunt and a big screen.



MSI WS65

Nvidia Quadro RTX 5000, 2.6GHz Core i7-9750H CPU

\$7,499 | <https://au.msi.com/>

18.13 MH/s | 0.00002592 BTC | 107 Watts

MSI's WS65 is a smart-looking, black-with-gold-trim, mobile workstation with a UHD, 15.6-inch IPS screen. With a scorching-high price tag of \$7,499 this is one professional tool whose purchase you'd probably like to subsidise with Bitcoin. However, the Nvidia Quadro 5000 workstation graphics favour accuracy over performance and are therefore unsuited to Bitcoin mining. While the power draw of 107W keeps the electricity price low, running all day only earns you \$1.20 in profit. Still, the WS65 is a fine machine and its professional designation means it's likely to be a tax write-off or purchased for you by your employer.

A great looking workstation for CAD designers. But it's poor for mining.



MSI GE66 Raider Dragonshield Limited Edition 10SFS

Nvidia GeForce RTX 2070 Super, 2.4GHz Core i9-10980HK

\$3,790 | <https://au.msi.com/>

34.98 MH/s | 0.00006434 BTC | 150 Watts

If there's a catwalk competition, this wins hands down. The paint job is designed by legendary concept artist Colie Wertz, who designed part of the Death Star in *Star Wars: Rogue One* plus the spaceship from *Galaxy Quest*. It has a 300Hz screen, is adorned with colourful LEDs and comes with a matching mouse. Its 2070 Super is getting old, but this means it's heavily discounted. It draws a modest 150W under load, functions comfortably at 72C and only offers a mild swoosh when doing so. The 34.98 hash rate helped it average a reasonable 6434 Satoshis (\$3.63 profit) per day.

A gorgeous, limited edition, statement piece that excels at everything.



@Getty Images

Tips and tricks for mining with laptops

We learned a lot when mining. Here's some advice...

Driver installation

The first thing you'll need to do is update your laptop's graphics driver (which can be different to standard desktop drivers). Doing this manually and getting it wrong can cause major driver failure that will require a tool like Revo Uninstaller to remove all traces of it. By far the safest method is to install Nvidia's GeForce Experience app and use that to select and install the correct driver.

Mining pool software

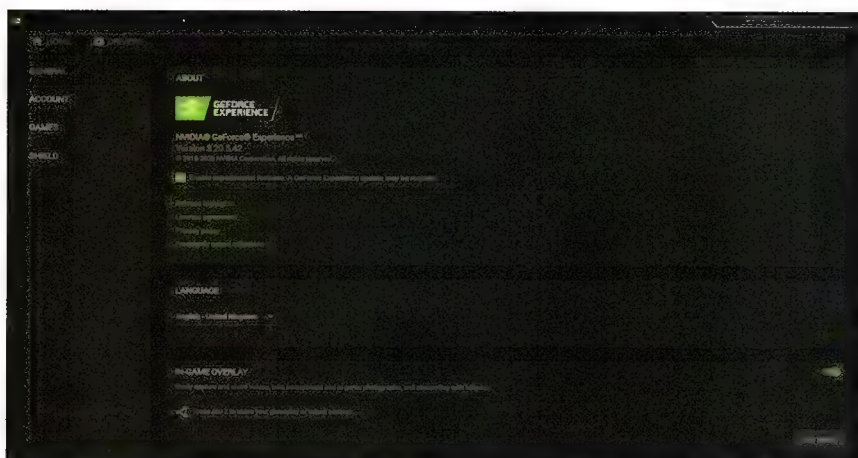
We used Nicehash for testing as the app is simple to download and setup, it's relatively secure and you can control and monitor your rigs over the internet. However, be sure to follow the guidelines on allowing the app to be exempted by your security software. Security suites HATE cryptomining apps and some, like Norton, won't let them through without being fully disabled. Disabling all of your security software is a very bad idea.

Electricity

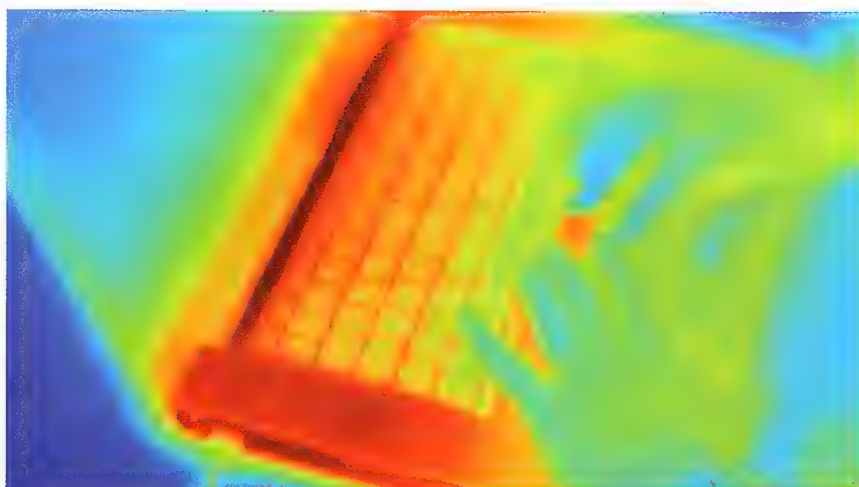
Most electricity providers charge you fixed rates throughout the day, even if the wholesale price drops very low. While it's true the price remains fixed for (very) occasional big wholesale price spikes, you'll still end up paying considerably more than the wholesale price with traditional providers. Meanwhile, new operators like Amber electric install a smart meter (for free) and charge you the wholesale price as it fluctuates throughout the day along with a low monthly membership fee. We were typically seeing 14 to 19 cents per KWh – almost half what some providers charge. You can view the proportion and price of renewable sources on the grid and choose the degree to which you utilise them. You also get warned if a price spike is occurring – which you can handily address by pausing mining via the Nicehash app.

Temperature

Laptops will mine consistently at very-high temperatures (even over 90C) but, as a general rule, the cooler they remain the faster they mine. The first thing to note is that you can't mine with the lid closed – they overheat quickly. Secondly, ambient temperature plays a



Don't over-complicate matters, just go with the Nvidia GeForce Experience app to find the right driver for your GPU and handle the installation.



“Laptops will mine consistently at very-high temperatures (even over 90oC) but, as a general rule, the cooler they remain the faster they mine.”

part in determining internal temperature which is a big deal considering Australian climate. Having a mining-laptop-cum-heater in a hot home will turn a room into a sauna, so consider that you may need additional aircon electricity to off-set temperature hikes. In winter, though, you can benefit from a rather-noisy, self-financing heater that can handily create a clothes-drying room in wet weather.

The main thing to remember is to ensure the laptop is on a hard surface (not a duvet or carpet), in a well-ventilated area (not in a cupboard) and not directly next to anything flammable (just in case).

Laptop coolers don't always work

We used a variety of laptop coolers when testing, but they often made matters worse. Some tried to blow the hot air coming out of the chassis back into the chassis. We also discovered that plugging-in a USB laptop cooler saw additional heat generated by power consumption at the USB port itself! This bolstered the heat of the entire computer and made everything run slower.

Using a cooler without the fan turned on can be very beneficial, as it increases ventilation around the base. However, this isn't the case for coolers which are designed to keep your lapt cool – they tend to be insulated with comfy padding and this allows heat to build-up. We found that less-powerful laptops benefited most from turning a cooler's fan on. Angled stands also helped by raising air vents and helping heat to escape.

While varnished floorboards didn't mind the heat, thinly-veneered surfaces could warp. When we ran out of surfaces we actually found that spare roofing

tiles, with their high density and channelled grooves, made decent semi-permanent platforms for mining laptops in a home.

Over and underclocking

Nicehash provides some automated overclocking features but they don't work with all laptops. Many gaming laptops offer basic overclocking settings but, on some occasions, they caused Nicehash to crash when we activated them.

Nicehash can also use the CPU to mine lesser cryptocurrencies in tandem with the GPU. However, we found the heat generated from simultaneous CPU and GPU mining slowed everything down considerably. Consequently, we turned all CPU mining off.

In some gaming laptops, we found that dialling down the CPU power was a good idea because high CPU temperatures were occurring despite only the GPU being used. To lower CPU performance, go to Power Options |

Edit Plan Settings | Change advanced power settings | Processor power management | Plugged in: 15%.

Fans

Every motherboard maker used to say, it's not a case of if a computer fan will break, but when. That's why desktop motherboards generally don't have fans on them anymore. However, all laptops do. With some running at a constant 6,000rpm, we cannot seriously expect them not to break if left on for months at a time. Breakage will considerably dent your profits and possibly kill your computer.

Dust

Do not perform laptop mining in a dusty environment. After a week, you'll start noticing dust build-up around the edges of vents. You won't be able to see all the dust ingested into the machine itself (without dismantling it). With internal temperatures sometimes exceeding 90C, we can't imagine this isn't a potential fire hazard. Gently vacuum and clean your mining laptop regularly.

Earning Bitcoin without a computer

After the 2018 crash, many cryptocurrency investors left their digital assets sitting in exchanges for years. With less activity (and fewer profits) the exchanges came up with a novel idea to benefit people with idle assets but who didn't want to trade. With the flow of cryptocurrency being reliant upon complex relationships between things like liquidity pools and staking, exchanges like Binance allow you to opt-into this infrastructure and earn profit on your holdings. It works in a similar way to bank interest but instead of rates approaching zero, Bitcoin interest rates can hit seven percent. Some special cryptocurrency offers can even see guaranteed returns of between 33 and 100 percent if you're prepared to lock yourself in long enough. ■



Mining will put a huge strain on your components and test the laptop's cooling to its limits. You'll need to not only take that into account, but also the effect increased heat output will have in the room.

System news

Mark Williams dislikes getting burnt by vendor lock in.

We must give credit where credit is due. Nvidia kicked off the Variable Refresh Rate (VRR) monitor revolution back in 2013 with its G-sync initiative – a proprietary adaptive sync technology using a special module that Nvidia developed that makers needed to include to enable support. With Nvidia's multi-year marketing efforts and evolution of the technology it has succeeded in changing the industry for the better – tear-free variable refresh rate bliss.

Unfortunately for Nvidia it was AMD's reaction and competing open standard technology, FreeSync (based on the industry standards body, VESA, Adaptive Sync) that got VRR monitors into the hands of most people. For quite a few years it seemed like the two competing technologies were going to remain at odds with each other with neither being able to work with the competing brands' graphics cards.

After waiting a few years and desperate for a monitor upgrade myself, I decided to purchase a G-sync monitor a few years ago and got on the VRR bandwagon. And it was glorious. Zero tearing with always smooth gameplay and no input lag like the VSync of yore used to induce. G-sync is so good that a relative of mine who is a high FPS competitive gamer (without a VRR setup) recently visited me and wanted to see what *Cyberpunk 2077* looked like with ray tracing on. Expecting him to be wowed by the ray tracing visuals, I was surprised that his biggest reaction was from the buttery smoothness of the game despite only running at around 50fps!

The effectiveness of VRR in games cannot be overstated. I lost sight of that recently when my Nvidia GPU started to die on me, and I was forced to buy a new graphics card. Given the current market with most GPUs sold out, I was forced to get whatever was available. In the end I settled on an AMD card that is quite a bit faster than my old Nvidia card, so I was looking forward to a nice uplift in performance.

Which I got, but I started seeing the famous lines in the middle of



"With a monitor only compatible with G-sync and an incompatible GPU, I was stuck with either Vsync on or off, both of which are not pleasant to use coming from buttery-smooth VRR with G-sync."



MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

my display in high-speed action scenes denoting that screen tearing was happening. My sublime VRR days had come to an end and the screen tearing was glaring and agitating.

With a monitor only compatible with G-sync and an incompatible GPU, I was stuck with either Vsync on or off, both of which are not pleasant to use coming from buttery-smooth VRR with G-sync.

That's when I found the Enhanced Sync option in the Radeon drivers. Equivalent to Nvidia's Fast Sync, this option allows you to not only run at uncapped frame rates, but it mostly removes screen tearing as well. It is still present at lower frame rates, as the driver allows some screen tearing in order to favour responsiveness (something Vsync cannot do), however the result is remarkably good – almost VRR levels of smoothness and barely any tearing.

So, while I have managed to find an acceptable work around for my lack of VRR, don't let your next monitor purchase lock you in. Nvidia has capitulated to the sheer volume of FreeSync capable monitors out there, and now supports FreeSync monitors via its G-sync Compatible program. While G-sync still is the superior

adaptive sync technology thanks to the embedded G-sync module in monitors that support it giving them advanced buffering and processing techniques not possible via FreeSync, the fact Nvidia never opened the technology up for others to use meant obviously that no one else can support it.

Monitors are generally a very long-term usage item, often good for multiple PC upgrade cycles, so when purchasing consider VRR compatibility and cross-brand GPU support. I picked the wrong side during the early years of VRR monitors, but thankfully these days more and more monitors are now FreeSync and G-sync Compatible. A G-sync Compatible FreeSync monitor will work with both Nvidia, AMD and Intel GPUs.

Buying a monitor that's only G-Sync capable, while great, and possibly the best experience you can get, will lock you into needing Nvidia GPUs for all future upgrades if you want to retain VRR support.

For those without an adaptive sync capable monitor, or an incompatible setup, turn on Enhanced or Fast Sync in your drivers. It's good enough that I'm not sure why it isn't automatically enabled by default when installing the drivers. ■

Market snapshot

An overview of typical systems in today's market.



\$3,999 | tinyurl.com/APC494SC0

Scorptec Computers Elite RTX 3070

This stunner of a system goes to town on the white theme, and does it well. Relative to the equally priced Aftershock system this month, it drops some GPU performance with an RTX 3070 instead of an RTX 3080 class card, but what it loses there it makes up with a generally superior CPU and a motherboard that can be upgraded to double the core count, a boon for production focused users. There is all the PCIe 4.0 bandwidth available on the board. With specs mostly the same elsewhere, the decision of which is best comes down to if you are heavily gaming focused (in which case go for the Aftershock system) or productivity focused, in which this system offers better prospects and future upgradability options.

CPU: AMD Ryzen 7 5800X **Cooler:** Nzxt Kraken X63 **Motherboard:** Gigabyte Vision B550 D **Graphics:** Gigabyte Vision GeForce RTX 3070 OC 8GB **Memory:** Corsair Vengeance RGB Pro White 32GB 3200MHz DDR4 **Storage:** Samsung 970 EVO Plus 1TB M.2 SSD, Seagate BarraCuda 2TB HDD **Power Supply:** EVGA SuperNOVA G5 750W **Case:** Nzxt Elite H510 White.



\$2,688 | tinyurl.com/APC494ARR

Arrow Computers Hawk

This gaming system is great for those wanting to play competitive game titles at high frame rates without breaking the bank. The CPU is one of the best available for gaming performance, which is typically the limiter in such titles when running the graphics at lower details to get that competitive edge. The paired RTX 3060 will certainly get you over 100fps in most competitive titles, but is definitely still the bottleneck in this system. That CPU will be good for several GPU upgrade cycles to come. The system memory is a letdown however, at some 1200MHz below Ryzen's ideal memory speeds, so there will be a performance drop as a result. Check with Arrow what motherboard and PSU will be included before ordering so you know what the future upgradability will be like.

CPU: Ryzen7 5800X **Cooler:** OEM **Motherboard:** Not specified **Graphics:** GeForce RTX 3060 12GB **Memory:** 16GB DDR4 2400MHz **Storage:** 500GB Solid State Drive, 2TB Hard Disk **Power Supply:** Not specified **Case:** Deepcool Matrexx 50.



\$3,999 | tinyurl.com/APC494AFT

Aftershock PC Hypergate Tundra

This impressive machine costs quite a bit, but you do get a quite highly specced parts list in return. Let's look closer. Firstly, the storage is nice and roomy with 1TB of NVMe SSD plus 2TB of HDD capacity. Memory is also impressively sized at 32GB of somewhat over the top (for Intel CPUs) 3600MHz DDR4. The PSU is a good wattage rating at 750W, affording lots of capacity for future upgrades. The water-cooled Intel 10700KF is a generation old now but is importantly only single digits behind in performance to the best in gaming. The star of the show, in the RX 6800XT, will get you RTX 3080-levels of rasterisation performance without costing anywhere near as much. If you're not after raytracing this is quite a beastly system.

CPU: Intel Core i7-10700KF **Cooler:** Aftershock Spectra Glacier Digital 240mm AIO **Motherboard:** Z490 Gigabyte Aorus Elite **Graphics:** Asus TUF OC AMD RX 6800XT 16GB **Memory:** 32GB DDR4 G.Skill Trident Z Neo 3600MHz **Storage:** 1TB M.2 SSD, 2TB HDD **Power Supply:** 750W **Case:** Nzxt H510i.

\$1,692 | tinyurl.com/APC494PLE

PLE Computers GTX Super Scope T

At a time when PC parts have crazy prices or zero availability, finding something affordable can be a challenge. This system, fortunately, has a palatable price without sacrificing much. The CPU is the tried and tested Ryzen 3600, a favourite of many for a couple of years now, and is still good in most situations. The GTX 1660 Super will be the main hold-back in games. Expect near 100fps in competitive titles depending on settings and around 70fps at 1440p. The lack of an NVMe SSD is disappointing, but understandable when keeping costs down. If gaming is your focus, we'd suggest to remove the HDD at checkout and upgrade the SSD to a 500GB NVMe drive and the system memory to a 3600MHz kit, you'll save a few dollars and get a better overall experience.

CPU: AMD Ryzen 5 3600 **Cooler:** OEM **Motherboard:** Gigabyte B450 AORUS M **Graphics:** eVGA GeForce GTX 1660 Super SC Ultra 6GB **Memory:** Corsair 16GB DDR4 Vengeance LPX C16 2400MHz **Storage:** Samsung 870 EVO 250GB SSD, Seagate Barracuda 1TB HDD **Power Supply:** eVGA GD Series 600W **Case:** Corsair 275R Airflow Black.



PC BUILDER

Budget

Competent.

Another month of drought, another month of ridiculous prices. Unfortunately, there's no longer any stock of graphics cards at their recommended retail prices, so what we're going to do is just list what GPU we would recommend you buy, and with a current typical street price, and leave it to you to secure whichever brand and model you are lucky enough to find available.

That does mean things are a little different from usual, and it's more difficult to compare these builds against those from last issue because we've been forced to sacrifice performance in the past to keep the cost reasonable, but going forward, it should give us a nice base to work around. Sadly, this drought doesn't look likely to abate any time soon, and with the fabs that are being built taking years before they start producing chips, we could be in this position for a long, long time.

On the Intel side, things haven't fared much better. Again, we've ditched any semblance of quality componentry with regard to the motherboard and memory, and just opted for the cheapest we could get our hands on. The Core i3-10100 remains the same price as last issue, no doubt in apprehension of the latest Rocket Lake launches. It could be a good



sign – that Intel's shifted its 14nm manufacturing over to the new architecture – or conversely, third parties could already be snapping up these parts as a precaution in case the latest 11th-gen chips are in short supply as well. The worst part about the situation is that the current Intel release schedule doesn't list any 11th-gen Core i3s yet either.

AMD INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	\$130
PSU	450W CORSAIR CV 450 80+ BRONZE	\$50
M/BOARD	MSI B450M PRO-M2 MAX NEW	\$89
CPU	AMD ATHLON 3000G	\$85
GPU	AMD RADEON RX 6700 XT 12GB	\$1,100
RAM	16GB (2X 8GB) CRUCIAL BALLISTIX @ 3,200MHZ NEW	\$130
SSD	250GB SAMSUNG 980 PRO M.2 PCIE 4.0	\$110
HDD	1TB SEAGATE BARRACUDA 1TB 7200	\$55
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$1,809

INTEL INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	\$130
PSU	450W CORSAIR CV 450 80+ BRONZE	\$50
M/BOARD	ASROCK B460M-HDV NEW	\$120
CPU	INTEL CORE I3-10100	\$170
GPU	NVIDIA GEFORCE RTX 3060 12GB	\$1,000
RAM	16GB (2X 8GB) CRUCIAL BALLISTIX @ 3,200MHZ NEW	\$130
SSD	250GB SAMSUNG 970 EVO PLUS M.2 PCIE 3.0 NEW	\$85
HDD	1TB SEAGATE BARRACUDA 1TB 7200 NEW	\$55
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$1,800

PC BUILDER

Mid-range

Decent.

Again, we're recommending the graphics card we believe is best suited to the build's position in our charts (aka 1080p, 1440p, or 4K gaming at 60fps plus), and giving the current street price.

GPU situation aside, our trusty Ryzen 5 3600 has seen no notable price increases. We've not heard anything official from AMD yet, but it's telling that even these older 12nm parts are now suffering from the chip shortages, too, as people work their way down the historic product stack in a desperate attempt to buy a "new" processor. We would recommend the Ryzen 5 5600X in its stead, but the newer chip, although available, currently comes in at \$150 more than the 3600, and we just don't think it's quite worth spending the extra cash, especially when the 3600 comes with plenty of PCIe 4.0 lanes anyway. Performance is better, sure, but is it better value? Not really. We've also managed to grab a slightly more affordable motherboard (\$5 cheaper, in

fact), courtesy of an updated variant of Asrock's Phantom Gaming 4. There's not a huge difference between the two – in a board-to-board comparison, the PCB layout is almost identical – but the heatsinks have shrunk, and you lose the DisplayPort in the rear I/O. The cooler's ever so slightly cheaper, too, so that's in our favor.

On the Intel side of the table, things are a little more chipper. The Core i7-10700K has come

down in price ever so slightly, and we've managed to shave some more cash off here and there. We've also plumped for some slightly spicier memory, at 3,600MHz, but if you're not using this system for anything more than gaming, we recommend dropping to a 2,400-3,000MHz kit. For both builds we're going with HyperX Fury sticks, which continue to offer value up there with the very best out there.



AMD INGREDIENTS

PART		PRICE
CASE	LIAN LI PCO11-DYNAMIC	\$200
PSU	650W CORSAIR RMX (2018) 80+ GOLD NEW	\$150
M/BOARD	ASROCK X570 PHANTOM GAMING 4S NEW	\$195
CPU	AMD RYZEN 5 3600	\$300
COOLER	240MM COOLER MASTER MASTERLIQUID ML240L RGB V2	\$100
GPU	NVIDIA GEFORCE RTX 3070 8GB	\$1,500
RAM	16GB (2X 8GB)HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ NEW	\$140
SSD	AORUS 500GB PCIE 4.0 NEW	\$120
HDD	1TB SEAGATE BARRACUDA 1TB 7200	\$55
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$2,835

INTEL INGREDIENTS

PART		PRICE
CASE	LIAN LI PCO11-DYNAMIC	\$200
PSU	650W CORSAIR RMX (2018) 80+ GOLD NEW	\$150
M/BOARD	ASROCK Z590 PRO4 NEW	\$260
CPU	INTEL CORE I7-10700K	\$480
COOLER	COOLER MASTER MASTERLIQUID LITE 240	\$100
GPU	AMD RADEON RX 6800 XT 16GB	\$1,750
RAM	16GB (2X 8GB)HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ NEW	\$140
SSD	500GB WD BLACK SN750 M.2 PCIE 3.0	\$100
HDD	1TB WESTERN DIGITAL CAVIAR BLUE 7200	\$55
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$3,295

PC BUILDER

Turbo

Stupendous.

Ridiculous prices aside, even if everything was fine, and there were plenty of chips to go around, we still wouldn't recommend the RTX 3090. It's a beast, but the performance gain over the 3080 is 10-15 percent for a card that costs near twice as much, and has hefty flaws regarding its backplate and memory cooling. Aftermarket solutions from AIB partners have improved on that, and if you intend to water-cool it, EKWB provides options for the Founders Editions, but still, that thing runs very hot.

Elsewhere, the builds haven't changed a great deal. We're seeing pleasing price stability in memory, storage and power supplies; but it's still not a good time to be a tech enthusiast or needing an upgrade. Amazingly (and we really don't understand why), the Core i9-10900K hasn't increased in price, but rather decreased slightly. Given its multicore prowess, and extra cores versus its newest sibling, the Core i9-11900K, we recommend picking up the 10th-gen variant over its new big brother if you're focused on any form of multithreaded workload that doesn't leverage Intel's Xe graphics processing tech.

We've also taken the opportunity with the Intel build to grab one of the newer Z590 motherboards. Not

only will this give you the opportunity to upgrade to an 11th Gen processor if you desire, but it also comes with Wi-Fi 6E support, and if you read our feature on that last issue, you'll know it's going to be seriously important in years to come. Buyers beware, however: We haven't had confirmation that Intel's 12th generation of chips will be backward compatible with these boards. If (and this is a big if, because we've been saying it for five years), Intel manages to crack 10nm, and deliver on its promises

this year of finally launching 10nm desktop chips with a derivative of the Cypress Cove architecture, there is no guarantee that they will operate in these boards. You'd hope so, but rumors are abound of DDR5 and PCIe 5.0 support – only time will tell.

As enthusiasts right now, our best advice is to tinker with what you have. Think about your cooling solutions, look at your peripherals. Sometimes you gotta make do with what you have out in the bush.

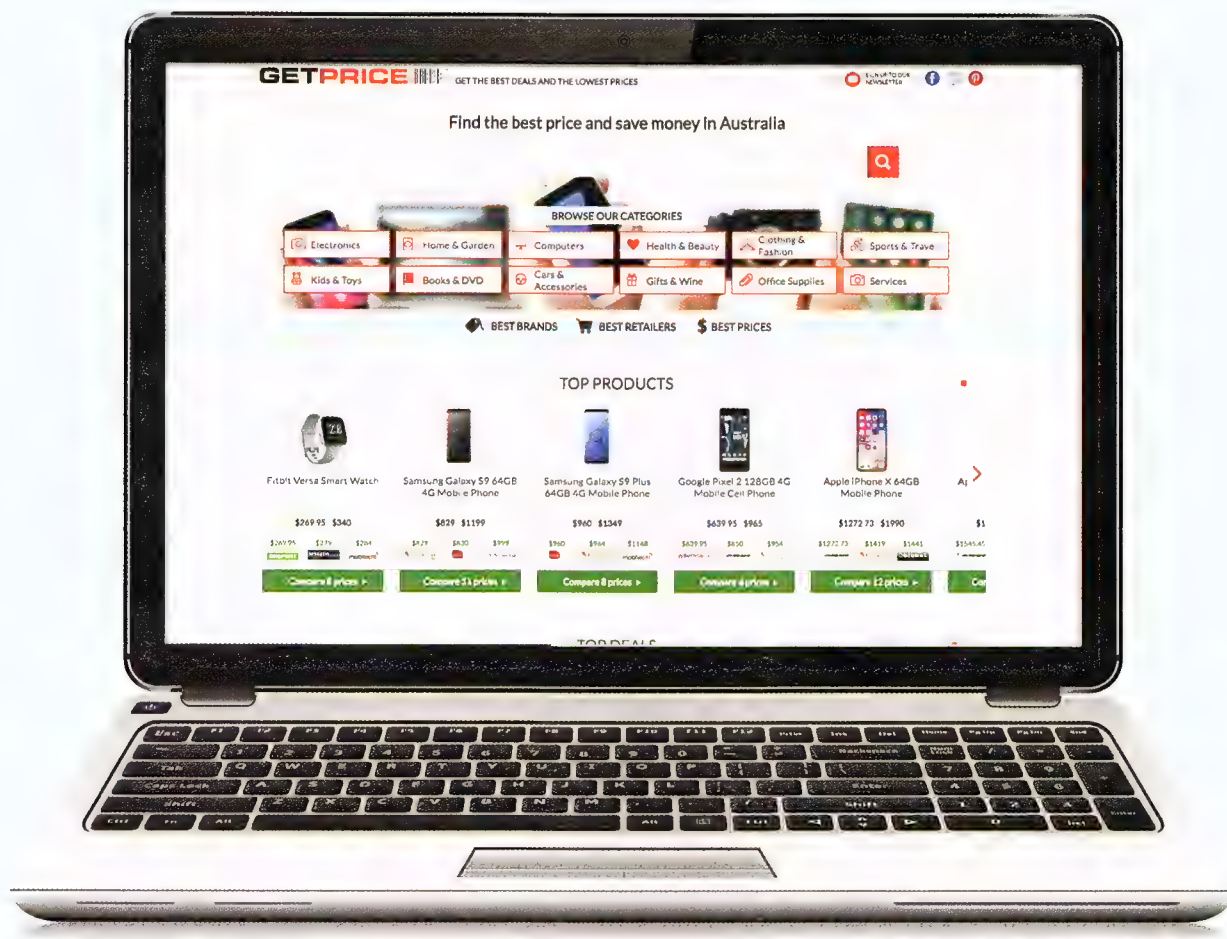


AMD INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	\$220
PSU	750W PHANTEKS AMP 750 W 80+ GOLD NEW	\$170
M/BOARD	GIGABYTE X570 GAMING X ATX	\$200
CPU	AMD RYZEN 7 5800X	\$720
COOLER	CORSAIR ICUE H150I ELITE CAPELLIX 360MM AIO	\$305
GPU	NVIDIA GEFORCE RTX 3080 10GB	\$2,100
RAM	32GB (2 X 16GB) HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ	\$220
SSD	1TB AORUS 500GB PCIE 4.0 NEW	\$300
HDD	6TB WESTERN DIGITAL BLUE	\$260
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$4,555

INTEL INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	\$220
PSU	750W SEASONIC FOCUS PLUS GOLD 80+ GOLD	\$170
M/BOARD	GIGABYTE Z590 GAMING X NEW	\$330
CPU	INTEL CORE I9-10900K	\$730
COOLER	NZXT KRAKEN X73 360MM	\$270
GPU	AMD RADEON RX 6900 XT 16GB NEW	\$2,200
RAM	32GB (2X 16GB) G.SKILL TRIDENT Z NEO RGB DDR4 @ 3,600MHZ NEW	\$200
SSD	1TB CORSAIR MP400 M.2 PCIE 3.0	\$220
HDD	6TB WESTERN DIGITAL BLUE	\$260
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$4,660



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IT'S TIME TO BUILD A PC.

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THE
ULTIMATE
BUDGET PC

Zak Storey gets his hands dirty and builds the cheapest rig possible.

It says a lot that when we first priced this system up a month ago, it was about \$120 cheaper – four weeks later, and the thing sits at \$545. Honestly, we feel like a broken record at this point, but the market is absolutely volatile right now, as unscrupulous folk and miners snap up every piece of hardware they can find. Even the budget end is suffering, sadly. We're finally starting to see some companies take action against this (namely Nvidia with its RTX 3060 plans), but it might just be too little, too late.

Our opinion? It's not likely to stabilise for another year, if that. Similar to the memory-shortage crisis three years back, there's just not enough fab time out there to cater for the entire market. Nonetheless, this got us thinking: what exactly is the cheapest system you can buy today, with new parts and decent performance, and get the most bang for your buck?

And with that simple question, the Budget Buster was born, a \$500-600(ish, depending on time of reading) masterpiece of super low-spec, low-price PC-building awesomeness. Genuinely, this build is one of the most fun ones we've done for some time. That might sound crazy, but there's something about getting back to the bare bones of PC building that's refreshing. It makes you think, it challenges you as you lose access to a lot of quality-of-life improvements, and it's good to see just what is available at the lower end of the spectrum in regards to parts and performance.

PC building's not always about crazy, high-end systems with \$6,000 worth of components, and enough RGB to light up the Sydney Harbour Bridge. In fact it's something we've always argued – the smaller your budget is, the more valuable your buck becomes when allocating it to separate components. So how did we do it? Read on to find out.

INGREDIENTS

PART		PRICE
PROCESSOR	INTEL CORE I3-10100	\$170
MEMORY	8GB (2X 4GB) CORSAIR VENGEANCE LPX DDR4 @ 3000 MHZ	\$85
MOTHERBOARD	MSI H410M-C PRO MICRO-ATX	\$120
STORAGE	240GB KINGSTON A400 2.5-INCH SSD	\$45
POWER SUPPLY	450W CORSAIR CV450 80+ BRONZE NON-MODULAR PSU	\$55
CASE	CORSAIR CARBIDE SERIES SPEC-05 ATX TOWER	\$70
TOTAL		\$545

"Honestly, we feel like a broken record at this point, but the market is absolutely volatile right now, as unscrupulous folk and miners snap up every piece of hardware they can find. Even the budget end is suffering, sadly."



CPU

Intel Core
i3-10100 \$170

WE'VE USED our trusty Core i3-10100 processor before, and it's still our budget chip of choice. Complete with four cores, eight threads, integrated graphics, and a comfortable 4.3GHz turbo clock speed, it's a fantastic option for anyone looking for a budget chip to sink their teeth into.

ALTERNATIVE PICK The AMD Ryzen 3 3200G is an epic alternative, and has similar performance. But is a bit more at around \$230.



COOLING

Intel stock cooler

INTEL'S STOCK cooler hasn't changed much in the last 10 years, and it's certainly not a patch on the likes of AMD's included Wraith coolers, that's for sure. However, the LGA 1200 version is slightly larger, and still does the job admirably.



POWER SUPPLY

450W Corsair
CV450 80+ Bronze \$55

PLEASE, please never skimp on your power supply! Ever. It's just a bad idea. In our case we've gone with the super-affordable Corsair CV450 80+ Bronze. It's a non-modular PSU, but comes with a three-year warranty and a 100,000-hour MTBF rate, so if things go wrong, we know we're covered.

ALTERNATIVE PICK For around the same price is an EVGA 450 BR – but whatever you do, stick with a named brand and a decent warranty.



CASE

Corsair Carbide series
SPEC-05 \$70

CHEAP and cheerful is the name of the game here, and for our chassis we've gone with Corsair's SPEC-05 ATX mid-tower case. It's roomy, has acceptable cable management, and can even support up to a 240mm AIO. Best of all, it comes with a red LED intake fan mounted up front, and an acrylic window, which is pretty fantastic for \$70.

ALTERNATIVE PICK The Metallic Gear Neo Silent is available for around \$80. Although airflow is a bit limited, it does come with tempered glass instead of acrylic.



Storage

240GB Kingston A400
2.5-inch SSD \$45

WHEN it comes to storage, compromises have to be made, and since this rig isn't really designed for anything more than light office work, we've ditched the larger capacity SSDs for something a little older, and a little more quaint. Kingston's A400 2.5-inch SATA SSD fits the bill here. It might not be as potent as modern-day drives, but with 500MB read speeds and 350MB write speeds, it should be able to handle light office work and web browsing.

ALTERNATIVE PICK At this price range we'd recommend staying away from QLC drives. However, you can pick up a 250GB Samsung 860 EVO for just \$10 more to max out write speeds.



Memory

8GB (2x4GB) Corsair
Vengeance LPX DDR4
@ 3000 MHz \$85

ANOTHER old faithful, Corsair's low-profile Vengeance memory is a perfect pick for this build. Although 8GB is a little on the low side, it should be enough for any office PC or simple home internet-browsing machine. Bear in mind, however, that our motherboard only has two DIMM slots, so if you want more RAM later down the line, it'd be wise to invest up front in a 16GB kit.

ALTERNATIVE PICK You won't find huge savings in memory right now at this spec, but G.Skill sells an Aegis 8GB kit for around \$65, albeit with a speed of 2400MHz, which is less than ideal for Ryzen.

Motherboard

MSI H410M-C PRO
Micro-ATX \$120

THE cheapest board we could find that's compatible with our needs, the MSI H410M PRO comes in a few designations. We're using the slightly older A variant, but the difference between that and the C is minimal. It's super-budget, comes with an M.2 slot, two DIMM slots, one chassis fan header, and a couple of SATA ports. Any downsides? Well, it only supports DDR4 up to 2933MHz, so you'll have to de-clock your memory by one level during BIOS configuration.

ALTERNATIVE PICK For an AMD equivalent we'd recommend grabbing an Asrock B450M PRO4. It comes with more DIMM slots, and better memory support too, for about the same price as our MSI board.





The Budget Buster

Get hands-on and build your own super-cheap system.

The concept around this is pretty simple – we just love the idea behind the Core i3-10100. When this editor first joined the tech industry, the crème de la crème of desktop processors was whatever quad-core, Hyper-Threaded chip Intel had to offer at the time. That was the end goal. Ryzen wasn't yet a thing, and anything more than four cores was relegated to the world of HEDT, which was a bit more inaccessible. Motherboards were more expensive, and memory costs immediately shot up whenever you mentioned the phrase “quad-channel.”

Fast forward to 2020, and with the launch of Intel's latest chips, this little beauty fell into our lap. Well, it was a special request we put in with Intel really, because bizarrely most agencies, PRs,

**LENGTH OF
TIME:** 1 hour
**LEVEL OF
DIFFICULTY:**
Easy

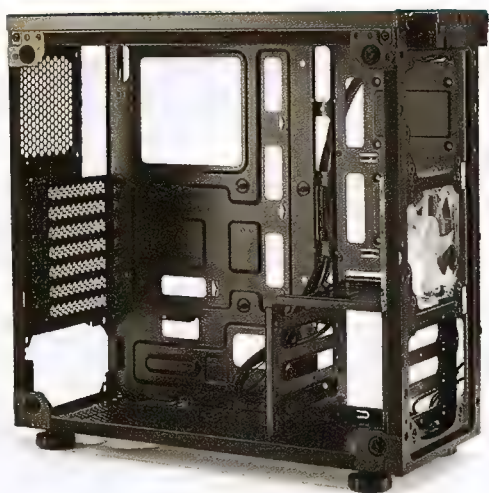
publications, and tech journo outlets don't spend a lot of time on the small stuff – which is a shame, because it's fascinating to see how an Intel Core i9-10900K or Ryzen 9 5950X gets filtered down into the lower specced parts, and how they perform in contrast. Many of you will remember that Christian built a solid “office” PC back in our Holiday edition that featured this chip. But this was in a lot of ways quite gluttonous: the price tag was just a bit too high, so it got us thinking; “What is the cheapest PC you can build with this processor at its heart?”

This is what we ended up with. It took a few months to get the parts together, mostly because, again, companies don't like showcasing their budget ranges, but after some nagging of

management, and a few expense forms, we managed to get everything together that we needed to make this little beauty come to life.

Now, you can make this build even cheaper. Instead of that Core i3-10100 you could pick up an Intel Pentium Gold G6400 for around \$100, swap the memory out for the G.Skill Aegis kit, go for the EVGA 450 BR power supply we recommended, and a Deepcool Matrexx 30 case for \$45. However, you would be cutting your core and thread count in half by doing so, and crippling your memory and CPU speeds in the process, which is not so good.

So with that all wrapped up, let's get to building this magnificent wee beauty, shall we?



01 STRIP AWAY

When it comes to building a system for the first time, it doesn't matter if you're a 20-year veteran, or an absolute beginner; the first thing you should always do is start with the case itself. Study it, analyse it, and then carefully remove the panels and place them in the case box, in between the Styrofoam packaging. This way you can ensure that you don't damage or scratch them, and you won't lose them either.

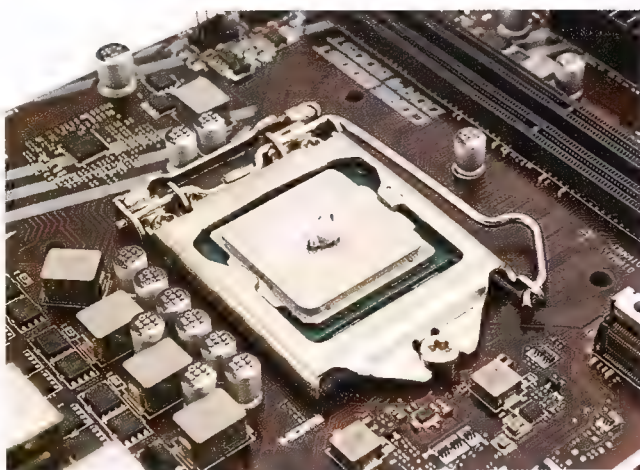
With the SPEC-05, this is a simple process. The front pops off from the bottom (carefully pull away from the bottom toward you), the rear panel is held on by two thumb screws (of the non-retainable variety, so pop these in a bowl, or somewhere you won't lose them), and then the acrylic windowed panel rather bizarrely comes off with hex key screws. After that you can remove the hard drive caddies, and put the small box of accessories out the way. Once that's all done your case should look like ours here.



02 PROCESSOR INSTALL

It's time to prep the motherboard. You can do this inside the chassis, but we recommend doing it outside the case first, so you can test the system before installing it, and if anything fails to function properly, it's a far easier job to disassemble the whole thing, get it boxed up and shipped back to the supplier or manufacturer.

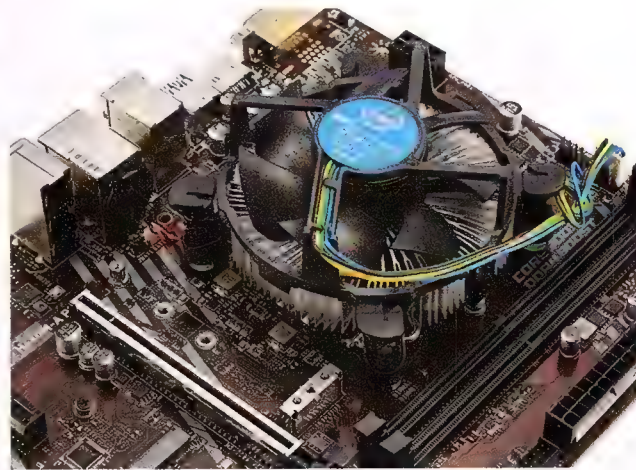
We've begun by installing the processor. This can be a bit sketchy with Intel, as the socket has pins in it that can be bent or broken. And if you bend them, not only will the system not boot, but you'll likely void the warranty too. To install the processor, lift up the retention arm, raise the bracket (leaving the plastic cover on), then carefully line your processor up with the socket, paying attention to the gold triangle on the bottom-left corner of the processor, and the socket, then gently lower it into place. Position the bracket down over the chip, under the Torx screw, and resecure it with the retention arm. The plastic cover should pop off.



03 THERMAL PASTE TIME

If you're building this stock, you can jump to the fourth step, as the stock cooler should have some pre-applied thermal paste on the bottom of it. In our case, we're not so lucky, so we've applied non-conductive Noctua paste ourselves. To do this, squeeze a splodge of the stuff into the middle of the processor like we've done below. Make sure it's at least the size of a grain of rice. You can add more - it won't affect performance in any meaningful way, but it does mean if you remove the cooler later, you may have some mess to clean up. Just make sure your paste is non-conductive, and that you meet the minimum amount we recommend.

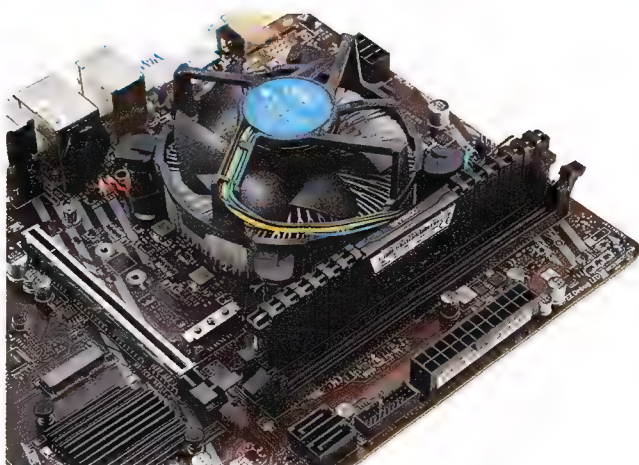
This varies according to the processor. HEDT processors require a line or star of paste, and AMD's Ryzen chips require a little extra too.



04 COOL BEANS

Now it's time to install the Intel stock cooler. If you've installed one of these before, we'll just say that nothing's changed with the LGA 1200. There's no backplate required, and no adjustments that need to be made. Make sure all four mounting pegs have the little arrow facing backward. Line the cooler up with the holes in the board, and carefully push it down until it clicks into position on each of the four corners.

Don't do what we did and assume you then have to turn those four pegs to lock them in place as the arrow suggests - weirdly that unlocked the cooler for us, so we had to remount it again. Then, unhook the fan cable from its mounts on the cooler, and plug it into the CPU fan header on the motherboard. In our case we've tied it into a little knot so it's a bit smaller.



05 MEMORY MOMENTS

With the cooler installed and the motherboard still outside the chassis, it's time to install the memory. Now, if you have a motherboard with four slots of memory, double-check with the motherboard manual which slots you should populate first. It'll likely be every other slot, but some motherboards prefer one set of slots to be occupied before the other.

In our case, as we only have two DIMM slots, we're installing our memory straight in. Lift up the tabs at either end of the slot, then carefully align your DDR4 memory so that the notches fit together. Each stick of memory and DIMM slot has a notch in it, so you can only install a stick a certain way. It's not the end of the world if you try installing it the wrong way – once you realise it's not sliding in, just remove it, spin it round, and install it again.



07 SNEAKY CABLES

So here's the workaround. We've installed the motherboard. To do that, install the additional stand-offs in their Micro-ATX positions included in the case accessory box – these are denoted on the chassis with an imprinted M-ATX text. Place your rear I/O shield in the case (making sure to bend the protector pins up and out the way of the ports), then place your motherboard in, lining the ports up, and secure it with screws when it's over the standoffs.

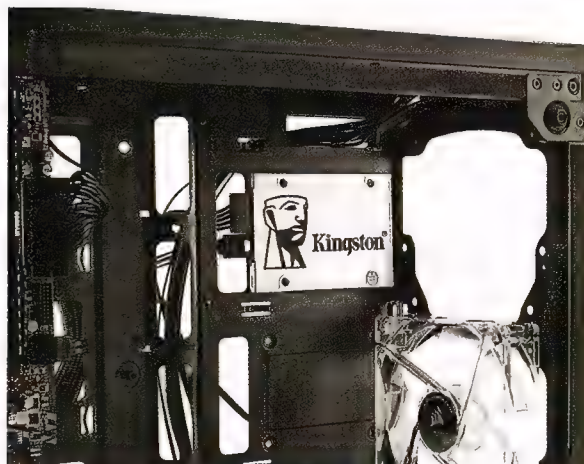
However, before that final step, we've run the CPU power cable round to the back of the motherboard tray, up through the cutout that usually gives access to the CPU backplate, then underneath the motherboard, and popped it out the top. Then it's just a case of plugging it into the CPU power. This keeps the rig looking clean and tidy, and doesn't hinder or cause any problems elsewhere. With that done, we've installed the 24-pin.



06 PSU CONSIDERATIONS

So here's an interesting step that we didn't originally intend to do. More often than not we always leave PSU installation until the very end – it's sort of the last piece of the puzzle in terms of cable routing and getting everything installed, and most chassis these days (at least the ones we use) have more than ample cable management to allow that to happen.

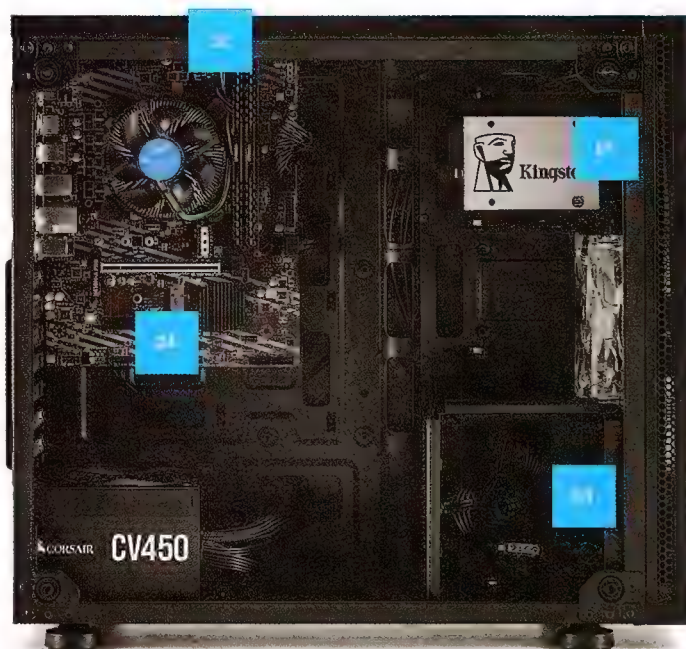
We noticed, however, that the SPEC-05 doesn't have cable cutouts at the top of the chassis to run the eight-pin CPU power through, so we'd have to trail it up to the power port, or run it along the top of the motherboard, both of which look grim. There's a nifty workaround, but we've got to install the power supply first to do it. Slot it in to place, then secure it with the thumbscrews provided with the PSU. In any other rig we'd recommend installing the power supply with the fan facing down, but we've installed it facing up to act as an exhaust.



08 SSD IDEAS

Last but not least, our SSD. Traditionally you're meant to install this in the back of the case in the motherboard tray, but we've decided to install it in the front – it's a nice feature to highlight, and we've got an acrylic windowed panel, so why not? Line it up with the cutouts, and secure it with four screws from the rear. Then install one SATA power cable (from the power supply), and one SATA data cable (from the motherboard box). We've gone with a right-angled data cable to make the mobo look cleaner, but it's finicky to get in the SSD, as that cutout is a little too small for installing the cable.

Once the SSD is in, secure, and powered on, it's time to wrap up the rest of the cabling. Refer to the motherboard manual for your front-panel connections for power, reset and power LED. Then install your USB 2.0 and USB 3.1 headers, and that final three-pin front intake fan, and you'll be good to go.



- 01 You can theoretically install a 240mm AIO in the front of the case here, although it may be a bit tight, and that hard drive cage is pop-riveted into place, so there's no removing it, sadly.
- 02 We've tucked the CPU fan cable down the side of the RAM to keep it out of the way, and not get tangled up if the case gets bumped or knocked. This fan's going to be doing a lot of work, so stopping it from spinning would be a death sentence for performance.
- 03 We've bundled the spare cables that we had together using cable ties, and then placed them in our empty hard drive cage. There's still plenty of space for two 3.5-inch drives on top if you need to do this.
- 04 If you want to upgrade later there's a PCIe 3.0 slot on the board for a full-length GPU, and an PCIe 3.0 M.2 slot as well.

La Fin!

And there you have it, our attempt at building the best-value super-budget PC possible today. And hopefully by the time you read this, it hasn't skyrocketed in price to \$1,000 or something ridiculous.

Nonetheless, we're quite proud of this build – it looks exceptionally clean from a custom PC perspective, even though we're using very budget-oriented parts, and managing to keep the cables tidy and out of the way has been a relatively painless process. Mounting the SSD in reverse so that it's facing toward the window looks pretty snazzy, and getting the CPU power cable behind the motherboard looks epic. Even though the board itself is only a Micro-ATX affair, all in all the system doesn't look

empty – in fact it's nice to see Corsair include cable cutouts specifically for those using Micro-ATX boards in this case.

The build itself was relatively seamless. We didn't come across any major hurdles, and the biggest bugbear stemmed from the way that acrylic panel is held in place. It has screws securing it to the case, but they require a hex key to undo, which is a bit annoying, especially if you don't have a set, and there doesn't seem to be any included with the accessories box (maybe we missed it).

Performance is right where we expected it to be. The i3-10100 does well, scoring high in Cinebench, and overall performs okay (yes that is actually a high score) in our gaming benchmarks. Throw a few indie games at this thing on low to medium settings at

1080p, and you can easily achieve 20-30fps. It blisters through web apps and office applications, and that's the real take-away from this kind of machine.

So in hindsight, what would we upgrade or change? Well, the SSD. 240GB is fine for what this rig is intended to do (in fact you could probably get away with 120GB), but those write speeds leave a lot to be desired. It's not noticeable now, but throw in that extra GPU and a game or two, and the extra write space would be much appreciated. On top of that, cooling is just, okay. The chip sits around the 86 C mark under load in a 23 C office. It could be much better – something extra like a Cooler Master Hyper 212 EVO would placate us.

That said, this thing is a fine little machine. It performs impressively where it counts with its price tag. Throw this together for a relative or your technophobic friends and it'll serve them well for years. ■

"The build itself was relatively seamless. We didn't come across any major hurdles, and the biggest bugbear stemmed from the way that acrylic panel is held in place."

APC LABS BENCHMARKS

Indicates best result

	Cinebench R15 Multi	CrystalDisk QD32 Sequential	CrystalDisk QD32 Sequential	Rise of the Tomb Raider	Total War: Warhammer II	3DMark Fire Strike	Price
	Index	Read MB/s	Write MB/s	FPS	FPS	Index	
Budget Rig	904	493	312	6	6	1,245	\$545
Zero-point	898	552	533	6	6	1,233	\$735

Our zero point consists of an Intel Core i3-10100, 8GB of HyperX Savage DDR4 @ 3000 MHz, and a 500GB Samsung 860 Evo 2.5-inch SSD. All tests were performed at 1080p at the highest graphical profile. Historical prices reported at time of writing.

HOW-TO

TOP TIPS TO TACKLE TECH TROUBLES

QUICK TIPS

APC experts solve computing problems

The APC team tackle problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Thunderbolt 3 support
Hi APC. I've been working from home for about a year. My work laptop is connected to a dual-monitor 180W docking station via Thunderbolt. The dock and all peripherals are mine, but the laptop belongs to the company. I want to use the setup off-hours by unplugging the Thunderbolt from the laptop and into a yet-to-be-built PC rig. How would I do that? I don't need the extra power from the Thunderbolt. Do I just need to make sure the motherboard I pick has USB-C?

JOHN OTTO

APC responds: While Thunderbolt 3 is backward compatible with USB-C, USB-C isn't compatible in return. That means you need to source a motherboard with Thunderbolt 3 support, which typically means one of two things. First, some higher-end boards come with TB ports on the board – one example is Asrock's X570 Phantom Gaming-ITX/TB3 Mini ITX TB3.

Others provide support for TB3 via an internal header that can be paired with a specific PCIe add-on card, usually from the same manufacturer and paired to specific chipsets – for example, Asus produces two separate cards. The ThunderboltEX 3 card works with older Intel chipsets,

while the ThunderboltEX 3-TR card is designed for the newer Z490/B460/H4670/B550 series mobos that have the 14-1 pin header, including the TUF Gaming Z490-Plus.

Password problem

I was using my Asus laptop when it did a security update, something it's done perhaps hundreds of times in the past. This time, when the small window for the PIN came up, I got the message, "Something happened and your PIN isn't available. Choose another sign-in option." The only two options it gives me is a password or PIN. I had never set up a password, so what do I do?

BRUCE NOREN

APC responds: Windows defaults to using your Microsoft Account credentials to log in, so unless you specifically set up a local user account (harder than it should be) when setting up Windows, you're logging into that account, using your PIN as a shortcut. Try selecting "Password" and entering your Microsoft Account password, which should allow you to log in. If it fails, and you have recently changed your Microsoft Account password for any reason, try the older password instead.

If you don't know what this is, and you don't see an option about



Moved key folders elsewhere? Don't forget to tell Windows.

"I forgot my password," which will help you try to reset it to gain access, visit <https://account.live.com/password/reset> in another browser to see if that works. If resetting it doesn't gain you access, you may have to employ the services of a third-party tool that can bypass or reset Microsoft Account passwords in Windows 10. One of the cheapest is PCUnlocker Standard (www.top-password.com/reset-windows-password.html).

Moving user folders

Hi APC. My main drive is an SSD that's getting too full. I installed a secondary HD to hold my music, pictures, videos, and documents. I followed a couple of articles that explained how to point the folders at the top of the "This PC" page ("Music," "Pictures," etc.) to the new drive, but it ended in disaster.

I followed the directions in one of the articles on my "Music" folder, and it successfully moved the folder to the new E drive. The problem is that it deleted all my music files. My big mistake was that I forgot to create a new backup first, so it took me two days to recover everything and get my C drive back to square one, although the association between some of the music files and the cover art was lost.

I don't know if the instructions didn't work because they were too old for all the Windows updates that came since, or if it was something I did wrong. Do you know of a simple, foolproof, way to migrate these folders without losing the links in "This PC"?

STEVE VANETTI

APC responds: The standard procedure is the same now as it has been since Windows Vista was released, but to avoid the potential for data loss, we suggest you set up the folders on your new drive (for example, "E:\Steve\Documents," "E:\Steve\Pictures,"



A select group of motherboards support Thunderbolt 3.

and so on), then copy across the content from your existing user folders to these folders. Once the files have been safely transferred, delete the originals.

Once done, open File Explorer to "This PC." Right-click one of your user folders in the "Folders" list at the top and choose "Properties," then switch to the "Location" tab. Click "Move," browse to and select the target folder on your new drive (so "E:\Steve\Documents" for "Documents"), and click "Apply." You'll be prompted to move existing files to this new folder – this is necessary to ensure Windows understands where the folder resides – so click "Yes," even though you've performed this step already.

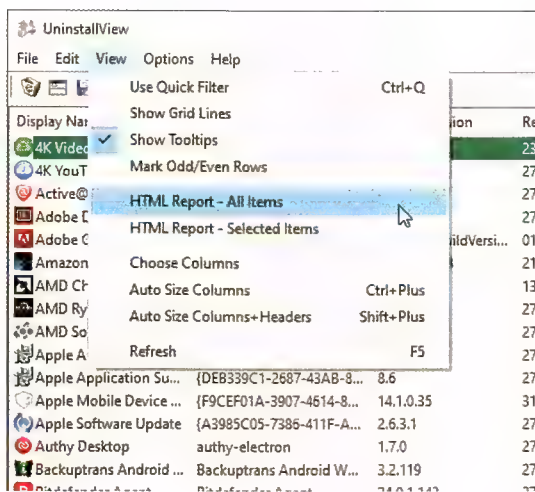
Windows is now directed to use the new folder, and you can repeat for any other user folders you wish to move. Going forward, we recommend you put in place a real-time backup of files with versioning support, so you don't encounter this again.

The simplest solution is to tie in these folders to a cloud backup account, but given the likely size of your music folder alone, this may be impractical if you don't have a premium subscription, such as Microsoft 365, which comes with 1TB storage via OneDrive. If you have access to a suitable file server (check out our guide to building your own high-powered NAS from last issue), the perfect tool for the job is NextCloud (<https://nextcloud.com>). Install the server portion on your NAS and the client on your PC, using it to back up all your key folders in real time. Alternately, go with Syncthing (www.syncthing.net), but be sure to configure the "File Versioning" tab during setup with one of the file-versioning options to keep multiple versions backed up.

CPU fan direction

I was puzzled by your answer to Papa Homey's question in February 2021's issue about CPU temperature fluctuation. How did you determine that all his fans were drawing air into the case? I've run Open Hardware Monitor and I don't see any way to tell which way my fans blow.
AL KRAYBILL

APC responds: If you reread the question, Al, you'll see that Papa himself revealed that all his fans



UninstallView generates a complete list of installed apps.

were blowing inward. This obviously isn't something that software can tell you – you need to open the case and visually inspect the fans to see which way they've been positioned to determine if they're pulling air out or drawing it in.

A couple of further points: One, make sure you leave enough space around your PC's chassis to allow the air to circulate, and two, there's no hard and fast rule about whether air should be drawn from back to front or vice versa. You may find colder air circulates more naturally at the front, in which case make sure your fans are configured so the air is drawn in from the front and expelled from the rear (don't forget to leave space behind the case). The key thing is to ensure the fans pull colder air across the components to draw the heat from them before venting it.

Installed software list

My Win 10 install is a couple of years old, so your article (March 2021) was welcome. However, the Powershell commands didn't work for me, at least not the second one to generate a text file in the root of drive C. I'm not clear about the character(s) following "Format-Table" and end up with a missing argument error.
WILLIAM BARNARD

APC responds: Apologies – there are a couple of errors with the way the command was formatted. It should be one long command, and there should be no space between “,” and “AutoSize.” The following is correct:

```
Get-ItemProperty HKLM:\Software\Wow6432Node\Microsoft\Windows\
```

```
CurrentVersion\Uninstall\* |  
Select-Object DisplayName,  
DisplayVersion, Publisher,  
InstallDate | Format-Table  
-AutoSize > c:\software.txt
```

If you'd prefer a simpler way that will generate a more comprehensive list of the software on your PC, try NirSoft's portable UninstallView tool, which you can download (choose the 64-bit version), extract, and run from www.nirsoft.net/utl/uninstall_view.html – once opened, a complete list is shown. Choose "View > HTML Report – All Items" to create an HTML document you can refer back to post-installation.

Email not working

I can't send or receive emails though Thunderbird anymore. When I check emails via my provider's webmail (<https://portal.tds.net>), all is well. I've tried contacting TDS tech support by email, and it's no help. All I get are canned responses that are on its site, and that it must be a problem with Thunderbird, as emails can be sent and received via webmail. Any suggestions?
RICH TAYLOR

APC responds: The problem will likely be with Thunderbird in the sense that TDS may have changed its mail server settings. We found conflicting advice from different TDS websites, but the latest information we could find would seem to point to the server recently having switched to a new system.

Click the "More" button and choose "Account Settings" in Thunderbird. Select "Server Settings" under your TDS mail account. Server Name should be set to mail.tds.net, and the port number will vary according to the Server Type: If it's POP3, this should be set to 995; if it's IMAP, set it to 993. Your username and password should remain unchanged.

Next, select "Outgoing Server (SMTP)," select your existing email settings, and click "Edit." Make sure the Server Name is again set to mail.tds.net, set connection security to STARTTLS (or TLS if you're running an older version of Thunderbird), and verify the port is set to 587. Click "OK" and hopefully you'll be able to use Thunderbird for your email again. ■

WINDOWS

Rolling your own NAS

Don't want to fork out for an expensive network attached storage device? Then just make your own.

Although their appeal has been somewhat diminished by the wide availability of streaming services, a network attached storage device is still a great addition to any home. It can keep your data, media and documents stored in a central location that is secure, private and accessible to every device on your network.

But while commercial NASs are cool, they're also expensive. And that's before you include the actual hard disks for storage, for which the sky is the limit on cost.

But you can also roll your own NAS using free software and an older PC that you might have lying around. A five or even ten year old PC is likely to have more power than the cheap ARM-powered commercial NASs.

So let's take a quick look at how you can do that, as easily and cheaply as possible.

The hardware

For a NAS, you only need a standard PC with as much storage as you're willing to pay for. A key limitation on some PC hardware is the capacity to add new drives, so you'll need a case that supports the drives you want to put in there and a system board with enough SATA/M.2/USB ports to support them.

A four-port Yateng PCIe SATA adapter, found on Amazon for \$45, would allow four more internal hard drives to be connected.

Although you can attach any type of storage you like, most commonly people will use standard 3.5in SATA hard drives since they provide the greatest capacity per dollar.

If you don't have enough SATA ports in your PC to support the number of drives you want, a cheap PCIe SATA host bus adapter will set you back \$50 or less. You don't need to buy an expensive RAID adapter – software raid or ZFS (see sidebar) will do the job for you. You may also need power splitter cables to support the extra power connectors needed for new drives.

The only other issue you might face with an older PC is memory, although that depends on the NAS software you use. We're going to focus on TrueNAS here, which does have some steep memory requirements thanks to its support for ZFS: 8GB minimum.

Finally, we should note that, once set up, the NAS can run "headless". It needs neither monitor nor keyboard to function and instead is controlled entirely through a web browser.



These things aren't cheap, especially the ones that are actually worth owning (QNAP TS-451 pictured).

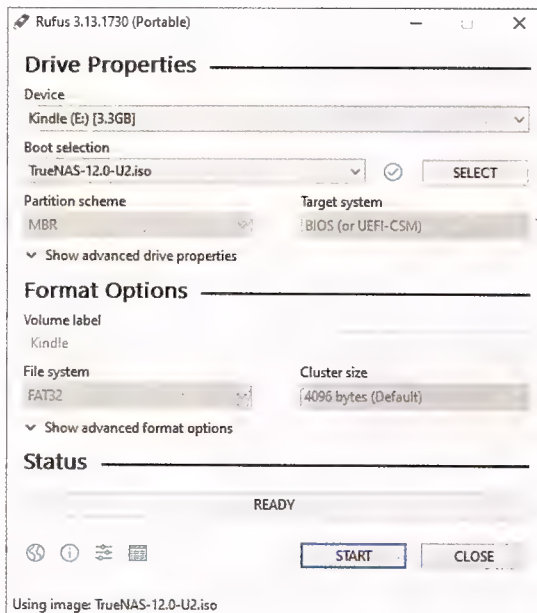
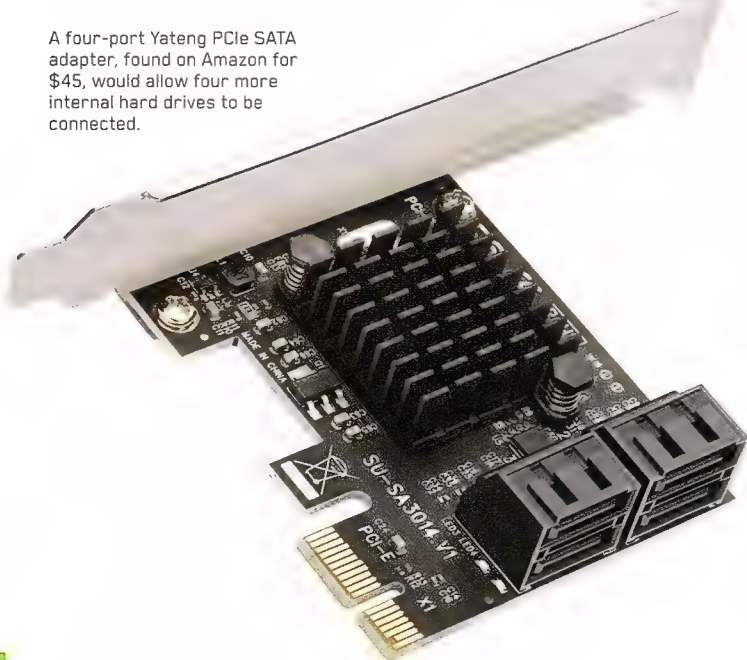
Make sure you select the correct USB drive in Rufus! Otherwise you might overwrite something important.

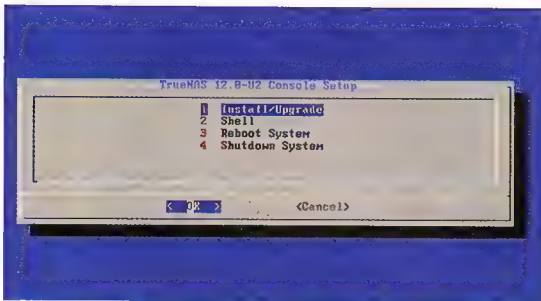
Now to the software

Once you have your hardware ready, it's time to install the operating system. There are actually a surprising number of different NAS operating systems available, nearly always based on some version of Linux. Some of the main ones include:

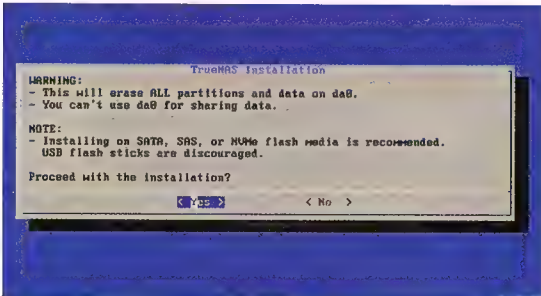
XigmaNAS (formerly NAS4Free, www.xigmanas.com). A powerful tool with ZFS and encryption, but a little complicated.

OpenMediaVault (www.openmediavault.org), a clean system with an easy UI and solid plug-in support.

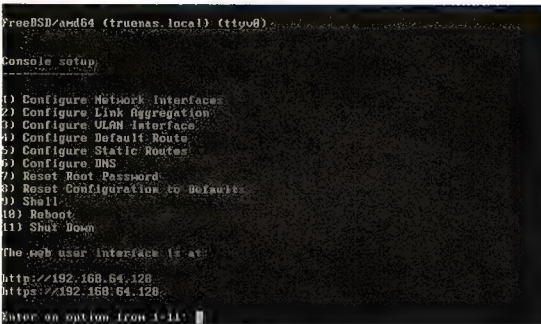




The initial setup screen.



Ready to rock.



You can configure some basic network settings on the device itself, but most management will be done via the web interface at the address shown.



TrueNAS' fancy new interface is much easier to navigate (and better looking) than the old FreeNAS interface.

Rockstor (rockstor.com), based on CentOS, is really great for remote access and personal cloud applications, with a simple GUI and solid plug-in support.

Amahi (www.amahi.org), one of the few that is genuinely built for home applications, with friendly add-ons and a polished interface.

We're going to focus here on TrueNAS Core, formerly known as FreeNAS (www.truenas.com), which is based on a similar platform to XigmaNAS but has fairly recently been redesigned to be more user-friendly.

Installing it isn't hard. First, you need to go to the official website and download the .iso file. This is a CD image file that you can burn onto a CD – just right click on it in Windows.

You can also put it on a USB drive, but to do that you'll need a tool like Rufus (rufus.ie). Download Rufus and run it. Plug in the USB drive, then select the TrueNAS .iso file and the USB stick. Rufus will copy the ISO to the USB stick and make it bootable.

Once you've done that, put the CD or plug the USB stick into the PC you want to turn into a NAS and boot it up. Hopefully the installer should appear and you can proceed. If it doesn't you may have a problem with your boot order – you'll need to go into that PC's BIOS and change the boot order so that the CD or USB is at the top.

You should soon be at the install screen.

Proceed, and you'll be asked which drive you would like to install the operating system on (it's recommended that you choose one

that won't be used for data storage). Choose the drive, and click to proceed.

Finally you'll be asked to enter a root password for the server, and whether to boot from a BIOS or UEFI. Which you choose will depend on which your PC has, but if you're not sure choose BIOS.

As with most OS installations, the process might take a while, and when it's done you'll be asked to remove the installation media and reboot.

There's one last thing to do on this PC, which is to make a note of the IP address. You'll need this to access the Web administration console. On bootup, there will be a text interface and it will tell you what the IP address of the NAS device is for web administration. Make a note of it.

You can now unplug the monitor and keyboard from the NAS. You no longer need them. Then go to any other PC in the house, and enter the IP address listed into the address bar of the browser.

The Web interface will appear, and you'll be asked to enter the root password for the NAS (or create one if you punted during installation). Do that, and you'll be in, with full access to the NAS. You're ready to create volumes and users, install plug-ins and services and much more. It can be a little overwhelming at first, and everything is turned off by default for security reasons (even SMB), so we'd suggest starting with the Guide button on the bottom left. Of course, if you're an old hand at this NAS thing, then you should have no trouble at all! 🟩

“Although you can attach any type of storage you like, most commonly people will use standard 3.5in SATA hard drives since they provide the greatest capacity per dollar.”

What's ZFS?

A computer file system is essentially a directory, telling the operating system what's stored on a storage device and where particular files can be physically found on the media.

There are different file systems in use. Windows uses NTFS and (for legacy devices) FAT. MacOS uses the Apple File System, while most Linux uses extFS. ZFS (originally called the Zettabyte File System) was designed to be the ultimate file system, and it's supported by some versions of Linux, including TrueNAS.

It has some key features that other file systems lack. For

one, it handles volume management and has an inherent RAID-like system where volumes can be spanned across multiple physical disks or implemented with RAID-5 style redundancy, where you sacrifice the capacity of one drive to provide failover in case of hardware faults in any of the other drives. You need at least three drives (preferably of the same capacity) to use this feature.

It also has several other reliability features built in, including snapshots, where it's possible to recover older versions of files.





MAC

Customise the Finder in Big Sur

Tune Apple's file browser to perfection with these tips.

IT WILL TAKE
5-10 minutes
YOU WILL LEARN
How to adjust
the Finder and
put handy
shortcuts at
your fingertips
YOU'LL NEED
macOS 11
or later

The Finder is such a core component of macOS, used by everyone every day, that we often take it for granted. Yet there are a lot of ways you can customise it to perfectly suit your needs, adding extra features or removing those you do not need to create a much more streamlined and tailored Mac experience.

In macOS Big Sur, nearly every

element of the Finder can be customised, from the folders and shortcuts in the sidebar and the buttons in the toolbar to the size of the icons and text displayed with each file. You can set your preferences to apply to a single folder or every folder you subsequently browse, based on your needs. You can even add a background picture if you like.

In this tutorial, we will cover

some of the most useful customisation options in the Finder, but there are many more we simply do not have space for here. Make sure you explore the Preferences menu, as well as all the choices you get in the View menu, to see what else is available to help you adjust the Finder however you want it.

ALEX BLAKE

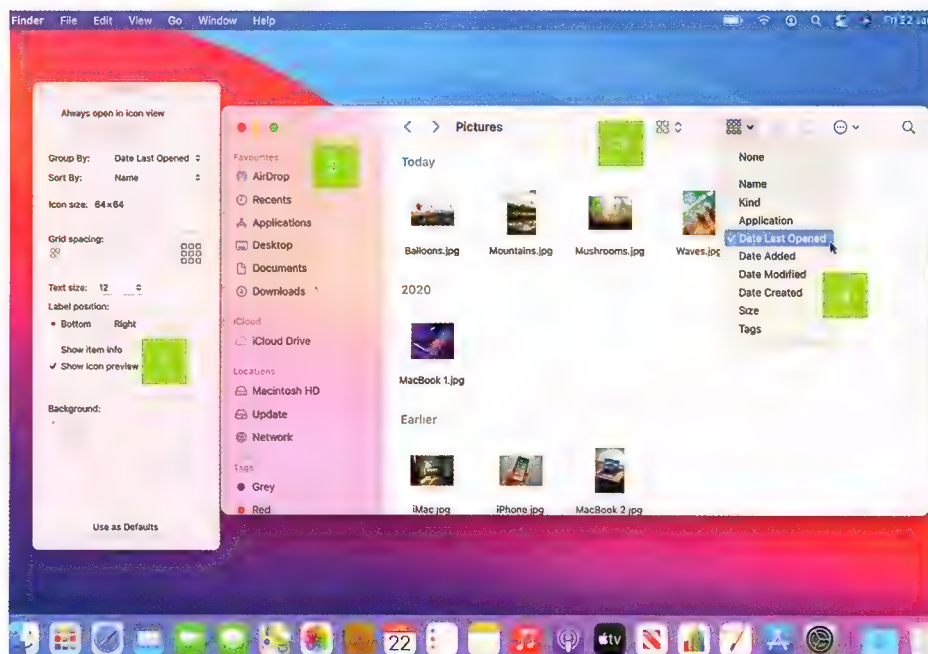
EXPLAINED... Finder in macOS 11

VIEW OPTIONS

This menu gives extra choices to tweak the Finder. Its contents depend on the view you are using.

THE SIDEBAR

Key Mac locations are shown here, as are tags and a customisable list of favourites.



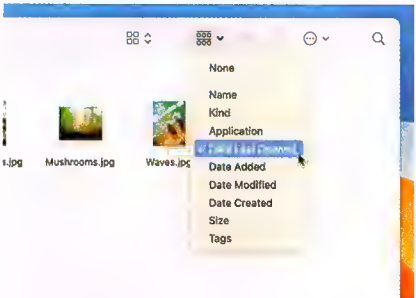
CHANGE THE VIEW

This button lets you switch between Icons, List, Columns, and Gallery views.

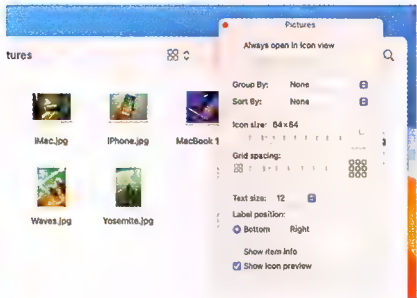
GROUP THERAPY

You can sort a folder's contents more easily with these grouping options.

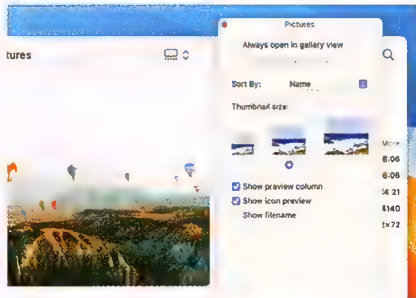
HOW TO Customise the Finder



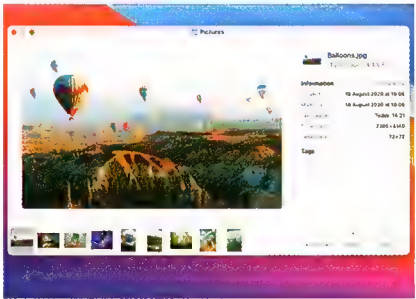
01 VIEWING CHOICES There are several folder views – Icons, List, Columns, Gallery – that you can access by clicking the view button in the toolbar. To the right is the item grouping button, letting you group files by date, type, and more.



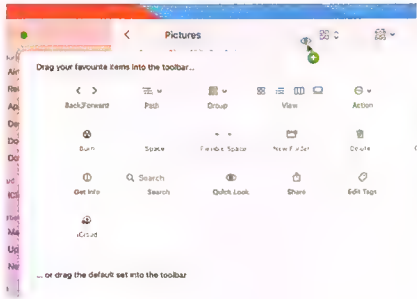
02 DEEPER OPTIONS Click View > Show View Options to get deeper options. Here, you can tell Finder to always open folders in your current view (such as columns), adjust the icon size, and change how files are sorted and grouped.



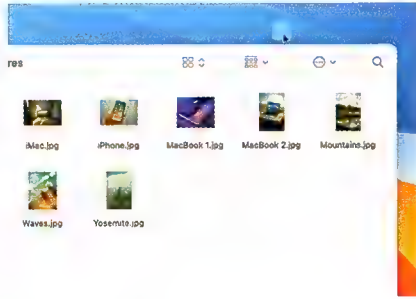
03 CONTEXTUAL OPTIONS Some view options change depending on the Finder view you are using. Gallery view lets you change the thumbnail size and add a preview column, while you can add a background picture or colour in Icons view.



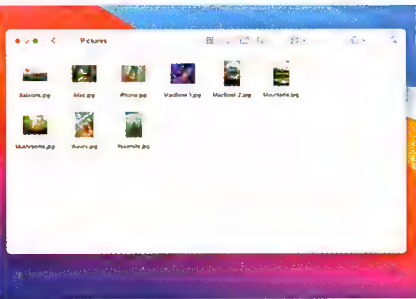
04 HIDE THE TOOLBAR To get a minimalist look, click View → Hide Toolbar. This will strip out almost everything except your folder contents, including the sidebar and status bar. To bring the toolbar back, click View > Show Toolbar.



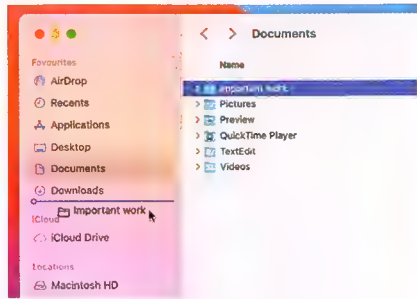
05 ADD MORE BUTTONS You can add buttons by clicking View > Customise Toolbar, then dragging a button onto the toolbar. You can also add files or even apps by holding command and dragging them to the toolbar until a green '+' button appears.



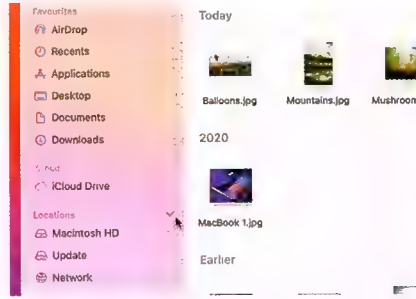
06 REARRANGE AND REMOVE If your toolbar is looking a little overcrowded, hold command and drag a button off the toolbar, then let go to remove it. You can rearrange items the same way – hold command and drag your desired button to a new position.



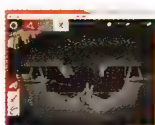
07 HIDE THE SIDEBAR Just like the toolbar, you can hide the sidebar if it is in the way. Simply click View → Hide Sidebar, or View > Show Sidebar to bring it back. Note that this will not hide the toolbar, which must be done separately.



08 ADD TO FAVOURITES The Favourites section lives in the sidebar. You can drag folders and disks to this section for quick access. To add an app here, hold command and then drag it into place. To remove something from here, drag it out of the sidebar.



09 COLLAPSE AND EXPAND Sidebar sections can be collapsed or expanded. Hover over a section header until a downward arrow appears, then click it to collapse subsections. To expand, click the arrow again, which will be pointing rightwards.



GENIUS TIP!
Lots of iOS games work well when played on the Mac. That said, do not forget to check if yours rely on your device's gyroscope for controls!



JARGON BUSTER
Mac Catalyst is Apple's tool for porting iPad apps to the Mac. Many of Apple's own apps use it, making them more consistent across platforms.



iOS

Run iOS apps on your Mac

Get cross-platform goodness for your apps in a few easy steps

When Apple announced its Macs were transitioning from Intel processors to its own M1 chips, one of the touted benefits was being able to run iOS apps natively on your Mac. And the really good news is that this is extremely easy to do, which we will outline in this tutorial.

That said, there are some things to be aware of. For one thing, macOS and iOS work in different ways. Mac apps can use multiple windows, for example, while iOS apps cannot; Mac apps are designed for mouse or trackpad control, not finger-based gestures. Not every iOS app has been

IT WILL TAKE
10 minutes
YOU WILL LEARN
How to download and install iOS apps on macOS
YOU'LL NEED
An M1 Mac running macOS 11 or later, an iOS device

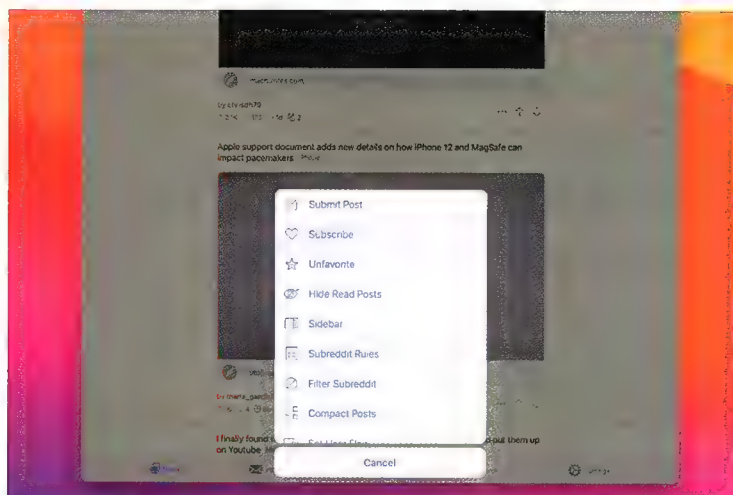
optimised for macOS, so running an unoptimised iOS app on your computer may not be quite what you expect.

When browsing the Mac App Store for iOS apps, look out for 'Not verified for macOS' in the description. If you do not see that text, it indicates the developer has taken the time to adapt the app for the Mac and is likely to therefore give you a better experience.

Mac Catalyst

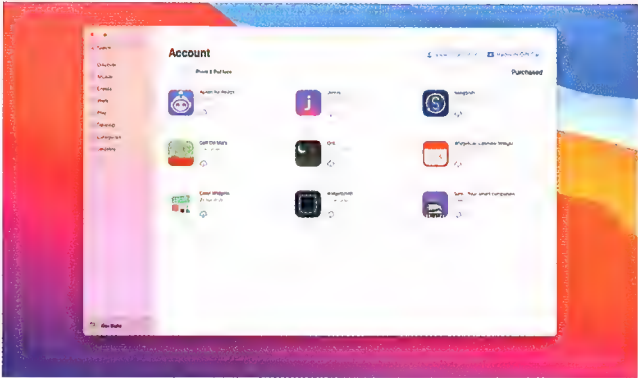
Some apps, though, may have had less care devoted to them when they were ported using Apple's Mac Catalyst framework (see the Jargon Buster). There is still hope, though, as there are plenty of ways you can improve these apps' functionality. We will take you through them in this tutorial, showing you not only how to run these apps, but how to make the most of them too.

ALEX BLAKE

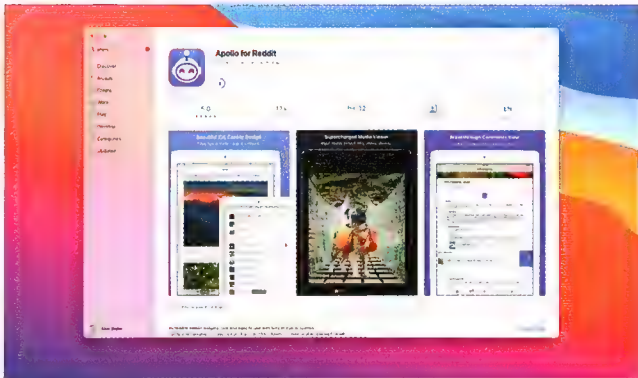


Even though many iOS apps are compatible on macOS and more than usable, be prepared for some things – such as menus – being designed with touch controls in mind.

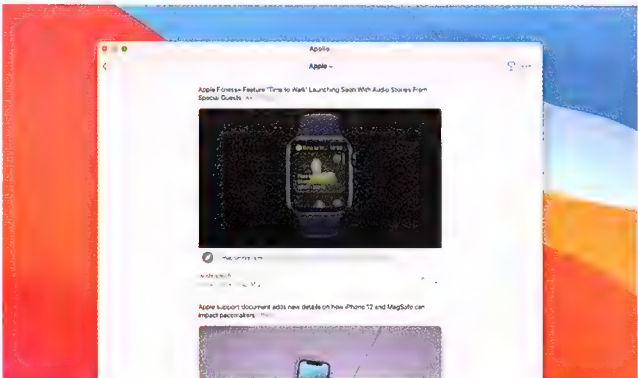
HOW TO Install iOS apps on macOS



01 YOUR APP LIBRARY Open the App Store app and click your username in the bottom-left corner. This will show a list of apps registered to your account. Click the iPhone & iPad Apps tab at the top to filter by iOS and iPadOS apps.



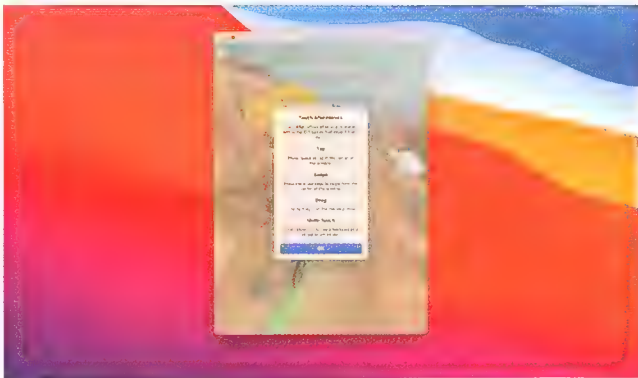
02 DOWNLOAD AN APP This will show every iOS or iPad app associated with your Apple ID. From the resulting list, find the app you want to install on your Mac. Click the cloud icon to download it and wait for it to install on your Mac.



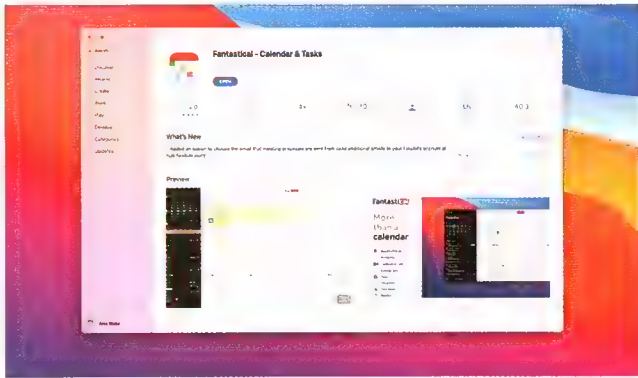
03 LAUNCH IT ON YOUR MAC When the download finishes, you will be able to launch the app. You can also install new apps by finding them the usual way on the App Store. Some apps may appear too small on your screen, in which case zooming helps.



04 INCREASE DISPLAY SIZE Open System Preferences > Accessibility > Zoom and tick the first two checkboxes. Click Advanced; in the next window, ensure the top option is set to 'Only when the pointer reaches an edge'. In your app, click View > Full Screen.



05 TOUCH ALTERNATIVES Many apps let you use your Mac's gestures instead of swiping as on iOS. Open an app and click its name in the top-left of your screen, then Touch Alternatives. This shows a dialog box with alternative controls for Mac.



06 USE THE MACOS VERSION Don't forget to check the App Store and your favourite developers' websites to see if they offer native macOS apps. Many popular iOS apps, such as Spark, Things, Fantastical, and many more, have native Mac versions. ■

Reduce spam emails

Shashank Sharma keeps the menace of spam at bay by using temporary email addresses from the comfort of the terminal.

While there are some reports of people receiving unsolicited messages in their mailbox as far back as the late 19th century, spam as we now suffer it dates back to the early iterations of the internet. Regardless of how careful you are in choosing where you use an email address, it's only a matter of time before unsolicited emails land in your inbox.

Of course, spam filters on email services such as Gmail are quite impressive, but false positives/negatives are regular occurrences. This means that genuine messages are falsely flagged as spam and worse still, spam messages manage to get past the filter and into your inbox.

Thankfully, there are many services that help you create disposable email addresses. 1secMail (www.1secmail.com) is one such service. It automatically deletes all messages received on user-created email addresses, and even the addresses are periodically trashed without user intervention.

In this month's tutorial we'll be looking into two utilities that

leverage 1secMail's API to help you create disposable email addresses from your terminal, and even read messages received on them.

Working with tmpmail

Released under the MIT license, the tmpmail utility is fairly straightforward to install and use. Its few dependencies include curl, jq, and the w3m web browser. The latter is a text-based web browser that the utility uses to display messages received on your disposable email addresses. There are many different text-based browsers available for Linux distributions, such as lynx and elinks, and you can also use any of these with tmpmail.

You can install all the dependencies on Deb-based distributions such as Debian and Ubuntu with the `sudo apt install curl jq w3m` command. The `sudo dnf install curl jq w3m` will do the same job on RPM-based distributions such as Fedora.

With the dependencies installer, you can download the tmpmail

QUICK TIP
Even though it's a command line utility, you can use tmpmail in conjunction with graphical browsers such as Chromium or Firefox to view email messages. The command `tmpmail -b firefox 124234740` will open the specified message in Firefox, instead of the default w3m browser.

script from its GitHub page by running the `git clone https://github.com/sdushantha/tmpmail.git` command. This creates a directory called tmpmail/ in your current directory, which comprises the tmpmail script. Move this script into any directory in your \$PATH, such as /bin or /usr/local/bin. You'll then be able to invoke tmpmail from anywhere on the terminal:

```
$ cd Downloads/projects
$ git clone https://github.com/sdushantha/tmpmail.git
Cloning into tmpmail:
remote: Enumerating objects:
100, done.
remote: Counting objects: 100%
(100/100), done.
remote: Compressing objects:
100% (74/74), done.
remote: Total 363 (delta 66),
reused 49 (delta 26), pack-reused
263
Receiving objects: 100%
(363/363), 175.47 KiB | 437.00
KiB/s, done.
Resolving deltas: 100%
(217/217), done.
$ cd tmpmail
$ sudo cp tmpmail /bin/tmpmail
[sudo] password for linuxlala:
$
```

As you can see, we've downloaded the latest tmpmail release and then moved it into the /bin directory. This enables us to run it as a command from anywhere on the terminal.

You can now create a new disposable email address by running the `tmpmail -g` command. This will automatically create a new email ID:

```
$ tmpmail -g
wgguinajbla@esiix.com
You can also specify a custom
email address along with the -g
command option: tmpmail -g
newtempadd@1secmail.org .
```

You'll notice that in the example above, tmpmail automatically generated an address @esiix.com while we just created an address for @1secmail.org. This is because the 1secMail service supports generating email addresses with the following domain names: 1secmail.com

Using the 1secmail utility

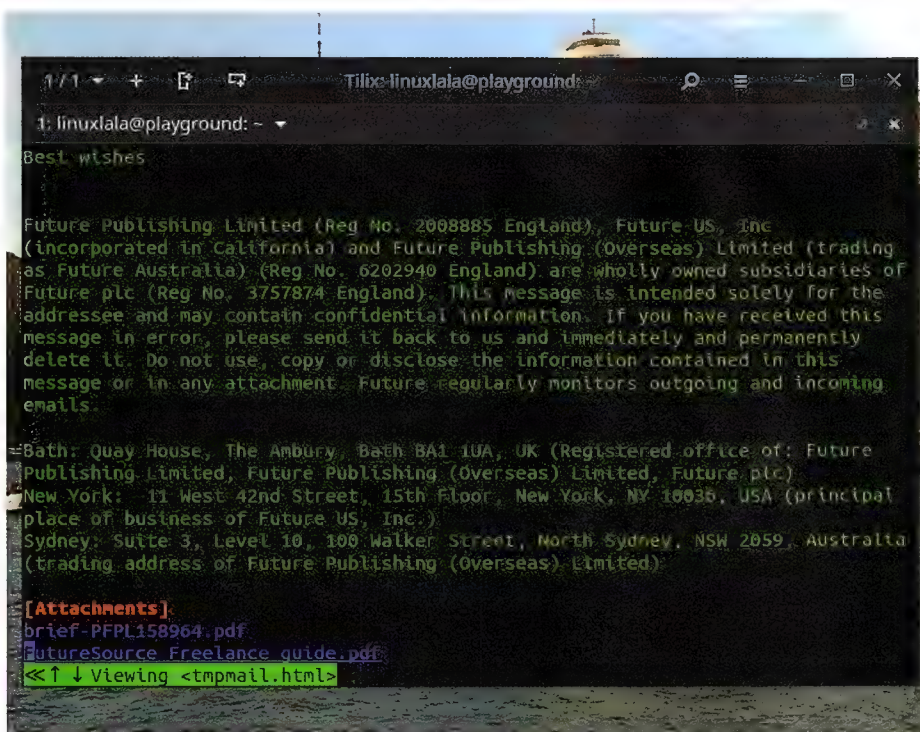
If you're willing to sacrifice the ability to receive attachments then there are several command-line utilities that provide similar functionality as tmpmail.

One such utility, which also uses the 1secMail service is called, unimaginatively, 1secmail. Its dependencies are the same as tmpmail. Run the `git clone https://github.com/KevCui/1secmail.git` command to download the project repository in your current directory. As with tmpmail, you can move the 1secmail script into a directory in your \$PATH for ease of use.

To create a new temporary email address, run the 1secmail command. You can create a custom email address with the `1secmail -u <email>@<domain>` command. The same command will display the contents of the inbox if the specified email address already exists:

```
$ 1secmail -u spammenot@wwjmp.com
[
{
  "id": 124281220,
  "from": "linuxlala@1secmail.com",
  "subject": "Great! Another temp mail utility",
  "date": "2021-02-03 11:52:28"
},
]
```

To read a message, you must specify the email address as well as the id: `1secmail -u <email-address> -i <id>`.



1secmail.net
1secmail.org
esiix.com
wwjmp.com

Run the `tmpmail` command, without any options for a list of all messages received on the most recently created email address. Each message is assigned a unique ID and you can read any message by specifying the corresponding ID:

```
$ tmpmail
[ Inbox for 123qwe@1secmail.org ]
```

```
124234740 sender@email.com
multiple attachments
124234613 sender@email.com
sending doc file as attachment
124234465 sender@email.com
yet another test mail
124212976 sender@email.com
another test mail
124195902 sender@email.com
test mail
$ tmpmail 124212976
```

Read your email

For each message in your inbox, `tmpmail` also displays the email address of the sender and the subject of the email. To read the most recent email, you can run the `tmpmail -r` command. This opens the email in the default browser, `w3m`. If you prefer to use another browser, specify it by using the `-b` command option:

```
$ tmpmail -b elinks 124212976
```

This command opens the specified message in the browser

The attachments, if any, are listed under the [Attachments] heading at the bottom of the message.

of your choice. By default, `tmpmail` displays the contents of the inbox of the most recently created email address. But this doesn't mean that it automatically trashes previously created email addresses.

```
$ tmpmail -g
spammenot@1secmail.org
spammenot@1secmail.org
$ tmpmail -g thisisme@wwjmp.com
thisisme@wwjmp.com
```

Here, both the email addresses are valid and active, but since we've created the `thisisme@wwjmp.com` address later, this becomes the default address that

`tmpmail` will display when you run either the `tmpmail` or `tmpmail -r` command.

If you want to view the inbox of the previously created `spammenot@1secmail.org` address, you'll have to run the `$ tmpmail -g spammenot@1secmail.org` command again. Now when you run either the `tmpmail` or `tmpmail -r` commands, `tmpmail` will display the inbox for this email address.

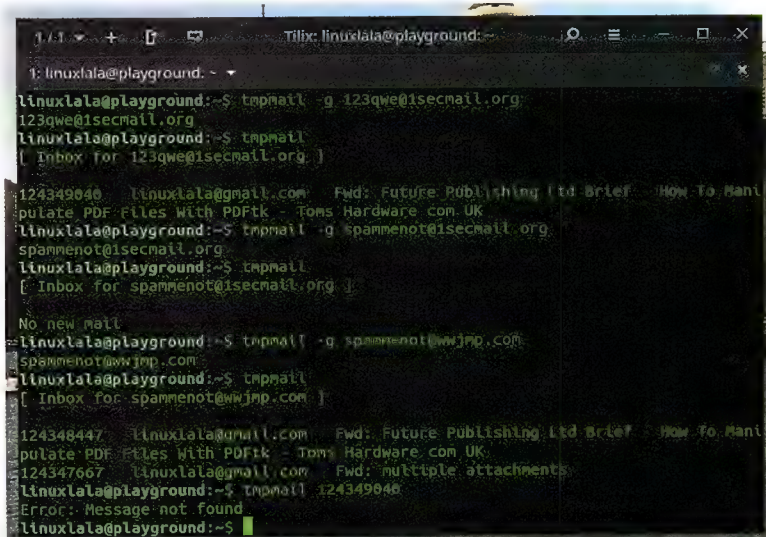
To clarify, if an email address already exists, running `tmpmail -g <email>@<domain>` command will switch to its inbox.

Working with attachments

Although the 1secMail service supports receiving attachments on your disposable email addresses, this feature has only recently been introduced in `tmpmail`. Unfortunately, its implementation isn't perfect.

We thoroughly tested the feature, and found that sometimes attachments failed to download. On other occasions the email was missing attachments. The latter was especially true in cases where you try to send multiple attachments. In some cases, a few attachments were stripped while others arrived without incident.

This may well be because of the size of the attachments, but there's not enough information available on the website of 1secMail or even `tmpmail` to shed light on the subject. We can only advise that you keep an eye out for news from the developers. ■



Even though each message is given a unique ID, you can't read messages from an inbox, without first switching to it using the `tmpmail -g <email>@<domain>` command.

Control real-world hardware on your PC

Mike Bedford shows PC users how to add GPIO interfaces to their computers, just like those Raspberry Pi and Arduino users are familiar with.

Users of Raspberry Pi and Arduino SBCs are familiar with these boards' GPIO (general purpose input/output) ports that enable them to interface to real-world electronic devices. PCs are devoid of GPIOs, but boards are available that provide that facility and connect to the PC via a USB port. Two such devices are the FT232H and the MCP2221, both from Adafruit, and here we see how to use them.

Our main emphasis is on hardware because we expect a lot of PC users who'll be interested in this topic probably won't have dabbled with SBCs and so won't have learned much about electronics. Having said that, we provide some Python code to get you started and show you how to learn more.

These two boards differ in their number of various types of GPIO pins. The FT232H has 12 digital in/outs but no analogue in/outs, while the MCP2221 adds three analogue inputs, one of which can be used as an analogue output, but only has four digital in/outs, and three of these share pins with the analogue in/outs. Note that these boards have USB C sockets, so to connect them to your PC you'll need either a USB C to USB A lead or, to use a common micro-USB to USB A lead, you'll need an adapter, as you'll see in our photos.

Installation and testing

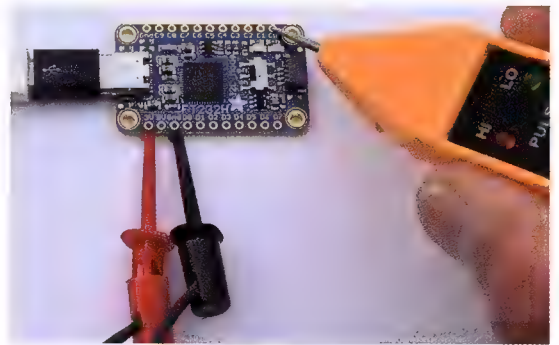
We'll be using Python to work with these boards. Although this will already be installed on your system, there are supporting elements you'll need to install. Since installation instructions are provided for the FT232H at <https://learn.adafruit.com/circuitpython-on-any-computer-with-ft232h/setup> and for the MCP221 at <https://learn.adafruit.com/circuitpython-libraries-on-any-computer-with-mcp221/setup> we aren't repeating that information here. Although you'll only see a Windows link, click it and then at the bottom of that page click Mac OSX and then the Linux link.

Despite seeing a few unfavourable reports, we experienced no difficulties at all under Ubuntu 20.04 LTS and were able to see both boards working in just a few minutes. Note that if you've already used the FT232H and move on to the MCP221 or vice versa, you won't have to follow all the installation instructions because you'll already have installed most of what you need. After installation, click the Post Install Test link and carry out those tests, then click Pinout, then Examples and finally GPIO.

That final link takes you to some simple Python code you can use to check out your board, so try the digital output exercise to ensure that everything's working. The instructions require you to connect an LED and a resistor to the board using a breadboard. You'll also need to have soldered the supplied headers to the board.

We'll cover these topics later, but if you have a logic probe, there's a much quicker and easier way of exercising the digital output code as an initial check. If you're going to be working with digital electronic circuitry, it would be beneficial to get hold of a logic probe because they cost as little as \$30. Most are provided with crocodile clips on their power leads, although so-called hook clips are much easier to attach to boards without headers. Separate leads with hook clips are available, though.

To use a logic probe on a board without headers, clip the probe's



If you have a logic probe, you can try out some simple code on the FT232H without having to build a circuit on a breadboard.

QUICK TIP

The FT232H board's name probably refers to the RS-232 serial interfacing standard. Now largely superseded by USB, it's still used in some applications, for example if you need to exceed USB's maximum lead length of 5m. If you have any equipment with an RS-232 interface, the FT232H enables you to interface it to your PC.

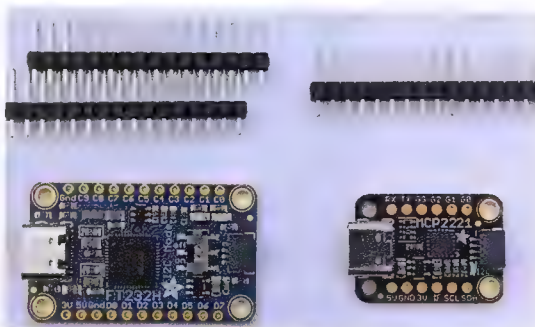
black and red leads into the GPIO holes for GND and 3.3V (the label shows 3V) respectively, and then touch the point of the probe on to the C0 GPIO for the FT232H or G0 for the MCP221. If that GPIO pin is at a high logic level then the probe's red LED will light; if it's low the green LED will light.

You'll be able to do that easily with the FT232H, but the MCP221's rows of GPIO holes are further from the edges of the board so you won't find it easy to attach the logic probe's power leads. You might find a workaround but if you're not careful you could short 3.3V to GND. That shouldn't damage the board because it has short circuit protection (but we're making no guarantees), although it would stop the board from working.

Hardware considerations

Before you do anything more with your FT232H or MCP221, you'll need to solder on the headers provided. First cut them down so you have two strips 11 pins long for the FT232H or six pins long for the MCP221. Plug the longer pins of the headers into a breadboard (more to follow) at the correct spacing and place your board on those pins, component side up, so the short pins pass through the two rows of holes. Now solder each of the pins to the surrounding pads on the upper (component side) of the board. See the box (below) for soldering tips.

If you're fitting headers to an MCP2221, unlike the FT232H, the two rows of holes aren't separated



The FT232H and the MCP2221 provide a good selection of digital and analogue inputs and outputs along with several serial interfaces.

by an exact multiple of 0.1 inches, as required to fit the board to a breadboard. Options are either to bend the header pins before you solder them to the board, or connect the MCP2221 to the breadboard using male-to-female patch leads instead of just plugging it in.

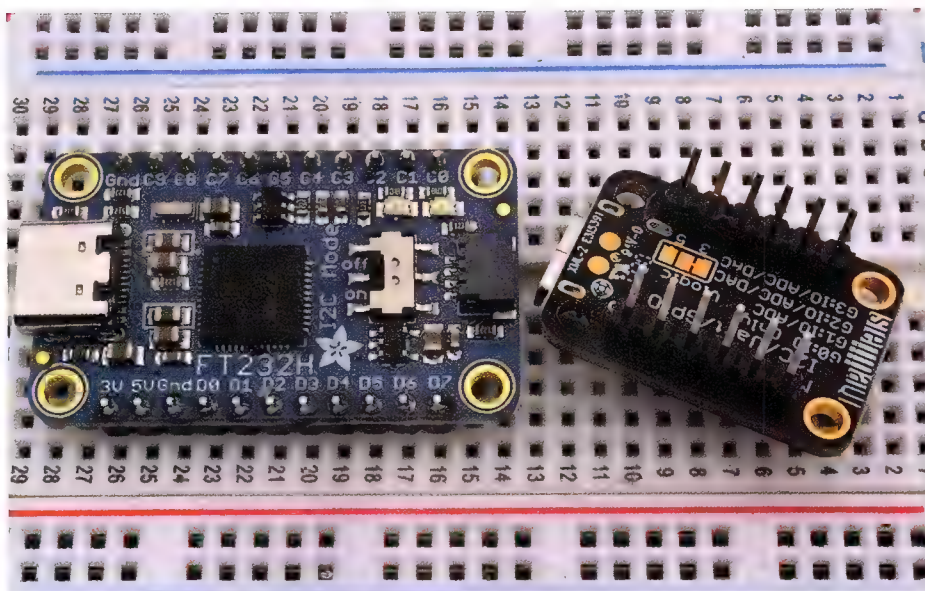
If you're new to breadboards, here's what you need to know. Breadboards are for trying out electronic circuits to check they work before building them permanently. They're also useful for learning about circuits or interfacing because they're easy to use and enable you to reuse all the components. They're plastic boards drilled with an array of holes that are connected together, electrically, inside the board.

If you push the lead of a component – such as an LED, a resistor, or a patch lead – into a hole, the board 'grabs' the lead, potentially connecting it to another component or patch lead. Those internal connections are along the vertical columns but with a break at the horizontal 'gutter' that runs across the middle of the board. We'll be plugging in the FT232H or MCP2221 straddling the gutter. The areas at the top and bottom of the boards are exceptions. The holes near the top and bottom edges (often the top two and the bottom two horizontal rows) connect together horizontally and don't connect to the vertical columns. These are intended for use as power rails, typically GND and either 5V or 3.3V.

Next you're going to need some electronic components including LEDs, resistors of various values, switches, potentiometers and perhaps an audible sounder. If you haven't got any components, the easiest solution is to buy a starter pack. These are widely available with a vast range of prices, but do check what's included before buying.

A first example

If we exclude the simple code that we've already used to test out the board, we're now going to present the first example code. It might just be the equivalent of the classic 'Hello World' example, but it involves both writing a bit of code and patching up a circuit on a breadboard. You can do this exercise on either on the FT232H board or the MCP2221, although the code is ever so slightly different, as we'll point out.



Here, both boards have had the header strips soldered on, as required to easily exercise them using external circuitry on a breadboard.

Even if you consider it to be trivially simple, though, we still suggest that you start with this example because our next exercise builds on it. It's rather like the exercise that we used to check the board out, in that it involves illuminating an LED, but that LED is now on a breadboard rather than on a logic probe, and it'll be lit up by pressing a button instead of by typing a command on your PC.

First of all, if you're using an FT232H, create a file containing the following Python code and save it with a suggested name of FT232H-example-1.py. If you're using an MCP2221, change C0 to G0 and C1 to G1 and save it as MCP2221-example-2.py.

```
import board
```

```
import digitalio
led = digitalio.DigitalInOut(board.C0)
led.direction = digitalio.Direction.OUTPUT
button = digitalio.DigitalInOut(board.C1)
button.direction = digitalio.Direction.INPUT
while True:
    led.value = button.value
    Now, wire up your breadboard as shown in the circuit diagram and photo on this page. The photo shows an FT232H, but if you're using an MCP2221, the patch lead that connects to the C0 pin goes to G0 instead, and the one that connects to the C1 pin goes to G1. These pins are in the top-right of the board (viewed with the USB
```

How to Solder

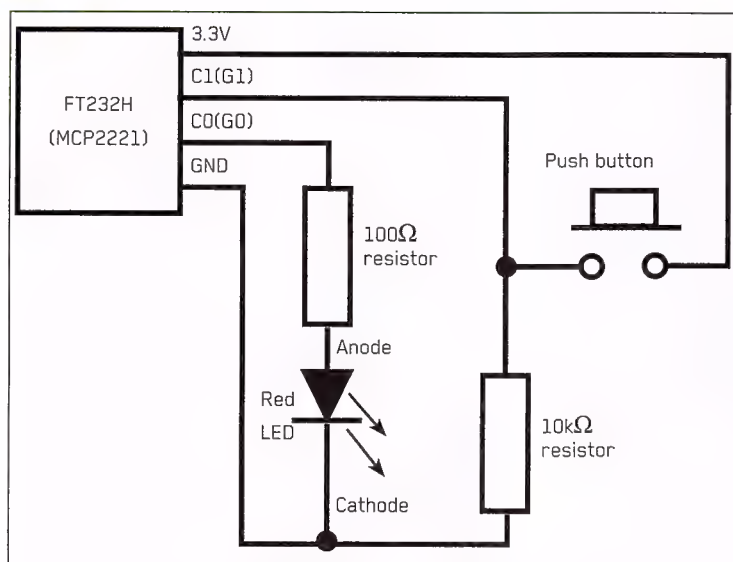
To use an FT232H or MCP2221, you have to solder the header strips on to them, but if you've never used a soldering iron, you might be wary of trying. That's understandable because if you make a mistake you could trash the board. Soldering isn't difficult, but you should read some tutorials first and practise before attempting to solder something that matters.

We suggest you get hold of some stripboard, otherwise known as Veroboard. This is an insulating board that's drilled on a 0.1-inch grid, and with copper strips on the back. It works much like a breadboard except that instead of just pushing leads into the holes, you pass them through the holes and then solder them on to a copper strip. It provides a means of prototyping that's more permanent than a breadboard, so it's something that's useful to have, not just for practising your soldering skills.

When you've tried your hand at soldering, use a magnifying glass to scrutinise your handiwork. First, solder joints should look shiny, but if they look dull – which is caused by applying heat for too long – it's a dry joint and means that there might not be a proper electrical connection between the component and the board. Second, adjacent solder connections shouldn't be bridged – in other words, shorted together. This can happen if you use too much solder.

QUICK TIP

A solder pump is a useful tool if you're going to be soldering because the occasional mistake is inevitable. It has a spring-loaded plunger enabling you to suck the solder off a previously made joint after you've melted it with your soldering iron.



The circuit needed for the code that drives an LED from a pushbutton. The header IDs are for FT232H – those for MCP2221 are in brackets.

connector at the left), just as they are on the FT232H. You can use a red, yellow or green LED, although if you use a blue or white one the associated resistor connected would have to be a different value.

Most components can be connected either way round, but LEDs have an anode (+ve) and a cathode (-ve) lead and these must be connected correctly. The anode connects to C0 (or G0) on the FT232H (or MCP2221) and the cathode connects to the resistor. The cathode is identified with a flat on the LED's round body, and usually also by having the shorter lead. The resistor that connects to the LED should have a value of 100Ω, signified by colour bands of brown, black, brown for a three-band resistor or brown, black, black, black for a four-band resistor. Our reference to the number of bands relates to the bands that specify the resistance, but there

will be additional bands you can ignore for now. The resistor that connects to the switch should have a value of 10kΩ, ie 10,000Ω, for which the colour code is brown, black, orange for three-band resistors or brown, black, black, red for four-band resistors.

With it all wired up, try it out. Enter `Python3 FT232H-example-1.py` at the command prompt (or `Python3 MCP2221-example-1.py`) and the LED should light when you press the button and go out when you release.

Before moving on, we need to say a bit about the circuit we used, why the two resistors are needed and why they're of the values stated. First of all, the resistor that's connected in series with the LED is there to limit the current and so prevent the LED from burning out. LEDs have a

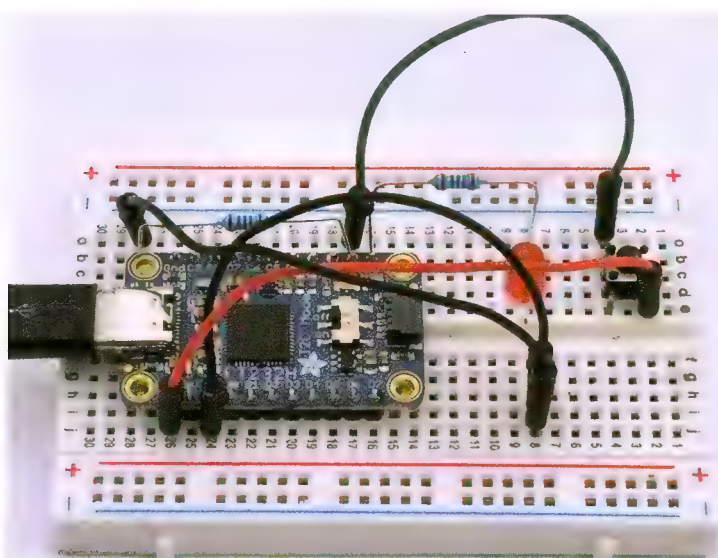
specified operational working current and a forward voltage. These are quoted in the specification sheet, but if you don't know the exact part number (likely if the LED was from a component starter kit), it would be safe to assume 20mA and 2V, respectively, for red, yellow or green LEDs.

The resistor must be selected, therefore, to ensure that the voltage across the LED doesn't exceed 2V. If you're using a 3.3V supply, as we're doing with the FT232H or MCP2221, we need to drop 1.3V across the resistor. Knowing the operational working current of 20mA (0.02A), we can work out the necessary resistance using Ohm's Law ($V=IR$, which can be re-written as $R=V/I$). In this case, that works out as $1.3/0.02$, which equals 65Ω. Resistors are only available in certain preferred values, and the value you calculate will almost certainly not be one of those, so you should choose the next available higher value. If you pick a smaller value, you might blow up the LED! In this case, 100Ω would be a reasonable choice.

The rationale for the resistor that's connected to the push button is different. The switch has to be connected between 3.3V and the input pin on the board's GPIO. So, if the push button is pressed, it would connect 3.3V to the input pin and the software would see this as a logic high level. However, with that circuit configuration, when the switch is released the input wouldn't be connected to anything so its value would be floating, ie undefined. So a resistor has to be added to provide a path to GND when the switch is open and thereby cause a logic low value to be read, but without causing a short between 3.3V and GND when the push button is pressed. The value isn't critical, but 10kΩ is a good choice.

It's called a pull-down resistor, but it's also possible to wire the switch between the GPIO pin and GND (but the code would have to be slightly different, otherwise pressing it would turn the LED off instead of on). In which case you'd use a pull-up resistor – one that connects to 3.3V. Although it's necessary to use external pull-down or pull-up resistors with these boards, many SBCs like the Raspberry Pi have internal pull-downs or pull-ups that can be enabled under software control.

Finally, we should explain the apparently strange colour coding that's used to identify resistor



Here's the physical implementation of the circuit that's presented as the circuit diagram above, which enables an LED and a pushbutton to be interfaced to an FT232H.

values. First of all, the colours are defined as follows: black=0, brown=1, red=2, orange=3, yellow=4, green=5, blue=6, purple=7, grey=8 and white=9. Now, for a resistor with three resistance bands, the first two bands represent the first two significant digits and the third band represents the multiplier, or the number of zeros. So, for example, yellow, purple, orange represents 47,000Ω or 47kΩ. When there are four resistance bands, those bands represent the first three significant digits (although the third will usually be black, representing zero) so in this case, that 47kΩ value would be represented by yellow, purple, black, red.

Build on the foundations

We've spent a lot of time describing the hardware because if you're a PC user who hasn't previously dabbled with Raspberry Pis or Arduinos, you're probably much more familiar with coding than electronics. You're probably more than capable of deciding how you can build on the software foundations we've already laid, but perhaps we can make a few suggestions because at least one highlights issues with controlling real-world devices that you might otherwise struggle with.

First of all, we suggest that you alter our first example so that, instead of lighting the LED only when the push button is pressed, it illuminates when you press it once, and goes out when you press it

QUICK TIP
Don't be tempted to try and interface an FT232H or an MCP2221 to mains-powered equipment via electronic components on a breadboard. It's possible to control mains-powered gear, but for safety reasons this should only be done with interfaces sold specifically for that purpose.

again. Modifying the code to do that might seem fairly simple but if you try it out you'll probably find it doesn't work.

In particular, pressing the push button might not always have the desired effect. This is because push buttons tend to 'bounce'. In other words, when you press a push button it'll turn on and off rapidly for a very short time before setting down to its 'on' state, and the same happens when you release it. If there's an even number of closures when you press the button, therefore, the software will act as if you'd pressed and released the switch multiple times so the LED wouldn't turn on or off. Only if the number of closures was odd would it behave as if you'd pressed it just the once. The easiest solution is to implement a delay of a few milliseconds after the software detects a switch going on or off so that the software doesn't see any bounces.

Next up, if you have an MCP2221, it's time to make use of its analogue I/O capabilities to build on the digital interfacing we've already seen. We're going to use an analogue input (ADC) because they're more commonly used than analogue outputs (DACs). Often the analogue device that you'll want to monitor is a sensor. For example, you could use a light sensor to detect dusk to turn on a light. However, we're going to suggest that you use something that's adjustable manually because that'll make it much easier to exercise your code.

The component in question is a potentiometer, which is the component used as the volume control on analogue radios. A potentiometer is a special type of resistor that, in addition to the contacts at both ends, has a contact that slides between those two ends as the control knob is rotated. It acts as a voltage divider. So, if the two ends are connected to GND and 3.3V, the voltage on the slider varies from 0V to 3.3V depending on the rotational position.

This, therefore, provides an easy way to generate a variable voltage that you can feed to an analogue input. If you add a potentiometer to the breadboard, an example you could try is to make the LED flash at a rate that depends on the voltage at the analogue input and, therefore, on the position of the potentiometer.

You'll be writing code in Python with the addition of the CircuitPython libraries, which add facilities for accessing the GPIO. We've presented one bit of sample code, but you'll need to refer to <https://learn.adafruit.com/circuitpython-essentials/circuitpython-essentials> to learn more about CircuitPython. You also need to know that the names used by these libraries to refer to the pins aren't always the same as the labels on the boards, so consult <https://learn.adafruit.com/circuitpython-on-any-computer-with-ft232h/pinouts> and/or <https://learn.adafruit.com/circuitpython-libraries-on-any-computer-with-mcp2221/pinout>. ■

Other FT232H/MCP2221 functions

Our emphasis here has been the types of interfaces normally associated with GPIO ports, namely digital and analogue input and outputs. These will probably meet most of your needs for interfacing with electronic components and sensors, but there are other interfacing options provided by our boards that you might be interested in.

The FT232H adds SPI, I2C, serial UART and JTAG, while the MCP2221 provides I2C and a more limited serial UART implementation. Both have a Stemma QT or Qwiic connector, which provides a more convenient way of attaching a I2C compatible device than by connecting it to the I2C pins on the GPIO headers. I2C is a standard for serial interfacing that uses two signals, namely clock and data, which enable data to be transferred in either direction between devices. Multiple I2C devices can be connected to the FT232H or MCP2221 because the standard includes a means of addressing so only one device will respond.

Qwiic was developed by SparkFun and Stemma QT by Adafruit, but the two are cross-compatible. Both companies, and others, offer a plethora of devices such as sensors (including light, pressure, temperature, humidity, distance, accelerometer and gyroscope), more complicated peripherals such as thermal imaging cameras, OLED graphic displays and GPS modules, and even novelty devices such as colour-controllable LED strips.



This sensor, for monitoring soil humidity in a plant pot or the garden, interfaces to an FT232H or MCP2221 via its plug-in Stemma QT interface.



STEM/CODING MASTERCLASS

Cracking the code: introducing the next-gen to STEM

The next generation will face many trials. The sooner we introduce them to science, technology, engineering and mathematics, the better. Darren Yates suggests how.

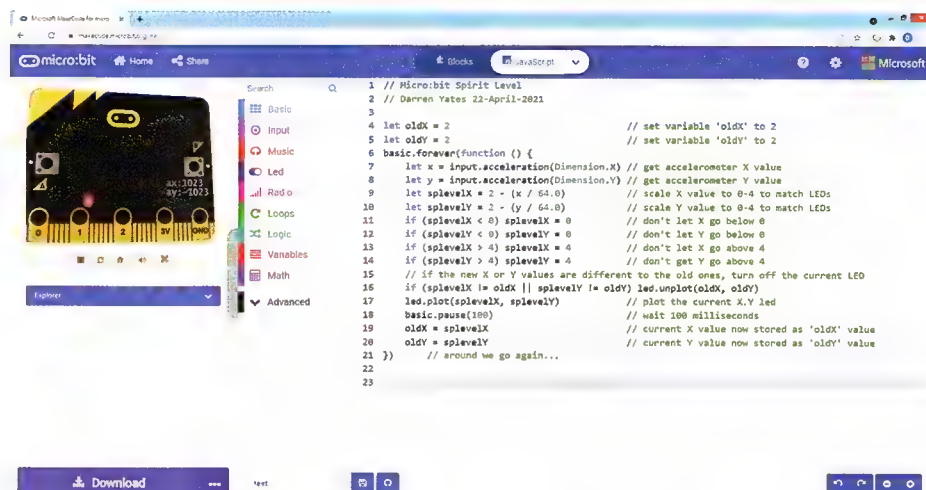
If nothing else, the last year or so has shown just how much our world now relies on the STEM disciplines – the collective areas of science, technology, engineering and mathematics (remember, maths is the foundation of the other three). That's why it's so important to encourage the next generation to not just use technology, but understand how it works, so that they can solve tomorrow's problems. If you're looking for low-cost inspiration to get your kids into STEM, here's where you can start.

Get practical

If you're thinking this is another 'get into coding' war-cry, it's not. We're way past that point. The speed at which our lives are transforming into the digital world means we are essentially left at the mercy of others if we don't at least understand coding concepts. Now before the pitchforks fire up, I'm not saying every child needs to become a software engineer – but I am saying every child should at least experience STEM.

That said, while there's no doubt that coding itself can be a pretty abstract concept, there is no field of human endeavour where it is not making an indelible impact. And that's a key to building inspiration in STEM more broadly – keeping it real and practical.

The great thing about growing up in the 1980s was that home



computers like the Commodore 64 weren't just about playing cool games, you had access to code your own.

Sadly, consoles have long lost that capability, but there are plenty of excellent alternatives that are low cost, fun and very hands-on. Here are just two.

BBC Micro:bit

Back in the 1980s, the British Broadcasting Corporation (yep, that BBC) joined with Acorn Computers to create the 'BBC Micro' series of computers. They featured in many Australian secondary schools, including mine. (Acorn later joined with Apple and chipmaker VLSI Technology to create ARM, the

You can even code a virtual Micro:bit board online for free.

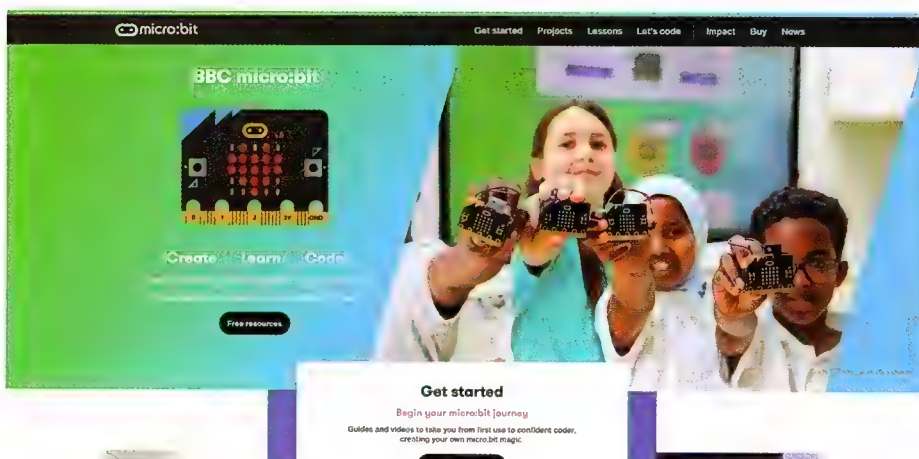
The new pocket-sized Micro:bit v2 board now adds audio capability.

designer of chips powering your phone).

Today, the BBC continues to promote computer literacy through its pocket-sized 'micro:bit' microcontroller board. It plugs into any PC via USB and you can code it with a variety of programming languages. What makes it so great are the practical fun features it comes with – there's a magnetometer (compass), an accelerometer (movement), pushbuttons and a 5x5 grid of LEDs. You even get Bluetooth wireless connectivity. Plus, the new version released late last year now adds a microphone and speaker.

You can buy a basic 'micro:bit V2 go' kit with battery pack, USB cable and micro:bit board for under \$35 from many local on-line maker stores (make sure it's version 2). There are also bulk packs (and pricing) especially for schools.

Make a compass, create music, code a door-bell, build a spirit-level, create hands-on games, control lights by speech, the list of things you can do with it is almost endless. Best of all, while Micro:bit has expansion options, the key features are built in, so you can just plug it into your PC's USB port, making it suitable for kids as young as eight.



Arduino

Micro:bit is brilliant as a first-stop, but when you're ready to graduate, Arduino is an excellent stepping stone onto greater things. Full disclosure: I love Arduino. For years, we had a monthly Arduino column in *APC* making also sorts of gadgets, from robots to digital audio recorders, using the popular Arduino makerboards.

Think of Arduino as the computing 'brains' that allows you to control external sensors, motors and other components. For example, if an ultrasonic sensor detects an obstacle, you can change a motor's rotation to change direction. Learn the basics of electronics, voltage and current-flow and you've got what I call 'Lego-on-steroids'.

Arduino is programmed with a simplified version of the C++ programming language using the free Arduino integrated development environment (IDE) on any Windows, macOS or Linux PC. You can buy Arduino makerboards on Ebay for under \$5 delivered.

Arduino does require some understanding of electronics as you're now working with electronic components, but with so many add-on boards now available, it's incredibly versatile. For example, Bluetooth and Wi-Fi options abound, there are boards to drive motors and LEDs. Learn those electronics principles and the sky's the limit (actually, these days, it's not).

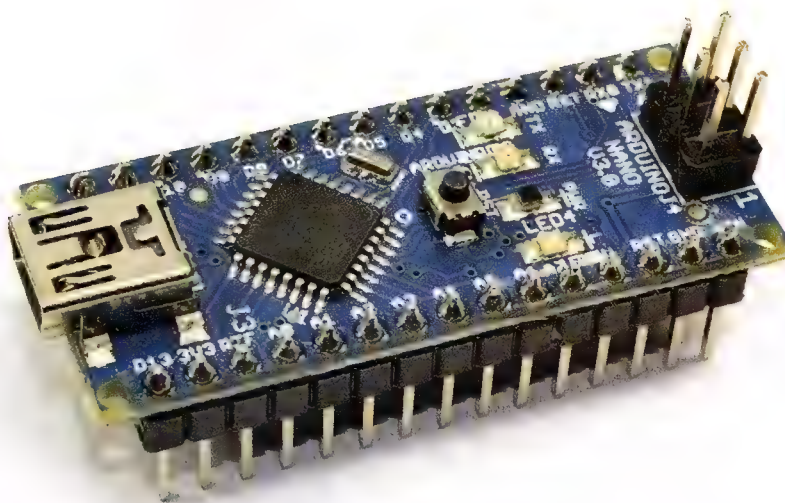
Teaching resources

Just from my previous experience taking part in the CSIRO's STEM Professionals In Schools program (www.csiro.au/en/education/programs/stem-professionals-in-schools), the rate of change in STEM alone has placed an incredible burden on teachers, both primary and secondary. They deserve huge respect (and more resources). If you have STEM skills and time to spare, consider volunteering with CSIRO's SPIS program.

From a teaching perspective, micro:bit is also a boon for its teaching resources. There are many class lesson plans (microbit.org/lessons) covering a huge array of areas from digital arts to geography, safety and security, electronics, music and more. Use them straight as-is or as the basis for your own ideas.

You don't even need to have a

The tiny Arduino Nano V3.0 makerboard sells for as little as \$5 online.



micro:bit board to get started – there's an excellent online micro:bit emulator at <http://makecode.microbit.org> that lets you write and run code for a virtual on-screen micro:bit board in either Blocks or Javascript. Code you write for the emulator also runs on the real thing, so it's a great introduction for students.

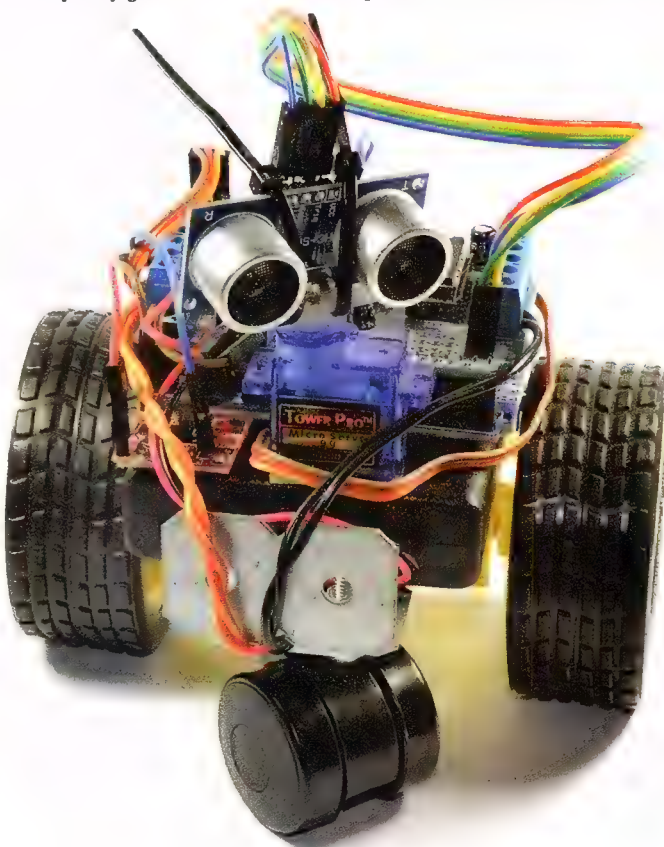
Raspberry Pi?

The Raspberry Pi is awesome, but it's a different beast. Being a full-blown single-board computer, it also needs separate power, keyboard, mouse, monitor, storage and operating system to get up and running. Arduino and Micro:bit obviously rely on having a computer system already, but being microcontrollers, they're essentially single-function devices with fewer initial requirements. Plug them into USB, code them and away they go.

Why 'practical' matters

Learning to code with little or no obvious practical outcome can be boring. It's also not what happens in the real world – coding is almost always part of a solution to a broader practical problem. Think COVID-19 and the race to create viable vaccines. Think cybersecurity that keeps your bank accounts safe, the lights on and the water running. Think agriculture and the need to grow food more efficiently, whether it's creating farm robots or using machine-learning to boost Australia's grain crops.

Learning to code is life-skill that will never go out of style but the growing need for new practical solutions for a range of problems means thinking more practically about learning to code is essential – for our generation and the next. ■



My spare-parts robot design, 'Rocket', built using an Arduino Uno board.

Some may recognise this diminutive machine from Black Mirror: Bandersnatch.



MACHINE OF THE MONTH

Sinclair ZX Spectrum

Emulating the coding icon with John Knight

At last, we're featuring the machine we've been teasing for months: the Sinclair ZX Spectrum. The machine was a cultural icon. Far cheaper than anything Americans were exporting, the homegrown Spectrum was a working-class hero that spawned a generation of influential coders.

Although the machine had cheap graphics and primitive sound, its rock-bottom price spawned a phenomenal budget gaming scene. For anyone willing to look past its shoddy presentation, an anarchic game culture awaits, with classic titles unlike any other system.

Development

The ZX Spectrum was developed under the leadership of British inventor Clive Sinclair, who was renowned for making electronics affordable through ruthless simplification.

Originally code-named the ZX82, the Spectrum built upon the ZX80 and ZX81 – machines that helped establish budget computing – but brought a wave of improvements.

Depending on the model, Spectrums had either 16 or 48KB of RAM, and were powered by Zilog's Z80A CPU. The microcomputer now had a colour display; the name Spectrum was

chosen to advertise its new eight-colour palette.

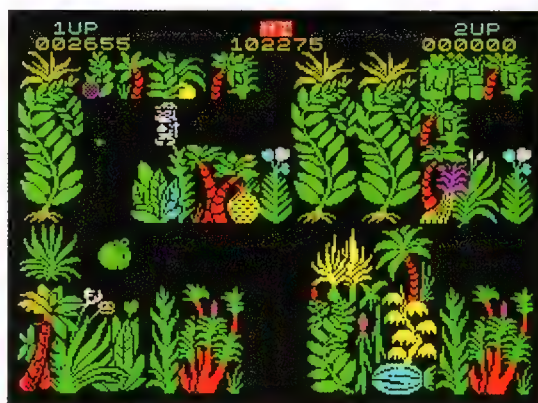
Unfortunately, it still had an awful keyboard. Its cheap rubber keys were unresponsive, with an infamous "dead flesh" texture. Sound was also primitive, with just a single-channel beeper. Due to memory constraints, games were usually plagued by colour clash whenever sprites crossed.

Launching in April 1982, initial prices were about the lowest of any computer you could buy, and prices soon dropped to the point where Spectrums were around half the cost of a Commodore 64, or a third of the price of Amstrad's CPC.

Gaming

While console owners had to continually save for new games, shelves filled with budget Spectrum titles. A thriving magazine culture featured cover tapes packed with games. Add in the system's rampant piracy, and Speccy owners soon developed large game collections. What Spectrum games lacked in style, they made up for in substance. They were often highly innovative and a goldmine for anything weird and different.

Although its graphics looked ghastly compared to the Amstrad or Commodore, the machine did



Sabre Wulf (1984) nicely demonstrates typical Spectrum graphics, with the psychedelic eight-colour palette, colour clash, and games mostly taking place at night.

have some tricks up its sleeve. It could outperform the Commodore in 3D games, and often had much sharper sprites compared to the blockier characters on rival systems. This sometimes resulted in richer environments, if you could look past the primitive colouring.

As for some gaming highlights, *Manic Miner* and *Jet Set Willy* are perhaps the most famous, and the *Dizzy* series was ubiquitous. *Exolon*, *Ant Attack*, and *Silkworm* are awesome. And for something a bit more punk, how about *Advanced Lawn Mower Simulator*?

Historical impact

The Spectrum truly brought computing to the masses, spawning more bedroom coders than ever before. This era put Britain at the forefront of programming talent and earned

SPECIFICATIONS CPU: Zilog Z80A @ 3.5MHz RAM: 16, 48, or 128KB Graphics: 256x192, eight colours Sound: General Instrument AY-3-8912 (128K) Storage: Cassette, ZX Microdrive, 3-inch floppy OS: Sinclair BASIC Released: April 1982 Production: 1982–1992 Worldwide sales: Five million

Clive Sinclair a knighthood.

Despite strong sales, issues with other products brought financial problems. Sinclair Research sold off its computing division to Amstrad in April 1986. Amstrad continued to sell Spectrums with improvements such as better keyboards, an improved sound chip, more RAM, and built-in tape or disk drives.

Spectrums were also heavily cloned. Timex was officially licensed to build clones, with poor sales in the US but strong sales in Poland and Portugal. Countless other clones were produced in Australia, as well as Eastern Europe and South America, and some clones are still being produced.

By the early '90s, sales were still much stronger than expected, with Amstrad focusing on 128K models as budget game machines. The Spectrum was eventually discontinued in 1992, with sales of around five million.

How do I emulate it?

There are many Spectrum emulators. We like Retro Virtual Machine (RVM), an emulator for the ZX Spectrum and Amstrad CPC.

Go to www.retrovirtualmachine.org/en and head to the "Downloads" page, where there are packages for Windows, Linux, and macOS. Windows users are given a ZIP file containing a stand-alone executable. Linux users are given a Debian package and a binary tarball, or can install RVM from the Snap store.

Starting with tapes

When you first open RVM, there will be a blank interface, but don't panic. Click the hamburger menu in the top-left of the screen to open the sidebar menu. Click the "Create machine" button.

A menu now appears with a choice of Amstrad or Spectrum. Choose "Spectrum," and click "Next."

The following screen has a selection of Spectrum models. The easiest choice is the +3e model, which has both tape and disk drives attached. After selecting a Spectrum, click "Create." You will return to the main screen with your model ready to launch.

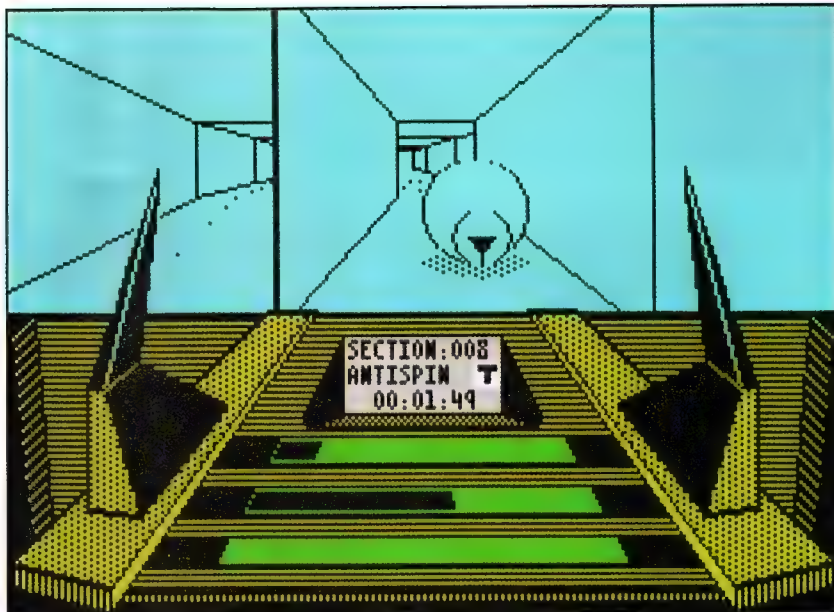
Clicking on the new Spectrum opens a new window with a blank emulated monitor. Press the power button located in the slide-down

YOU'LL NEED

A COPY OF
RETRO
VIRTUAL
MACHINE.

32 and 64-bit
versions are
available
for Windows
and Linux,
plus a 64-bit
package for
macOS.

[www.
retrovirtual
machine.org](http://www.retrovirtualmachine.org)



Micronaut One (1987) is an example of the Spectrum's 3D advantage, still providing other-worldly experiences today. © Nexus Productions, 1987

menu at the top of the screen.

Newer Spectrum models have a boot menu with the option "Loader" or "Tape Loader." Press Enter and the Loader waits for you to load a cassette.

Back in the slide-down menu at the top-right is a cassette icon. Press this and a large tape drive appears. Press the "Eject" button to select a tape image, then press the "Play" button to get started.

LOADING DISKS

To load a disk, first restart your machine with the "Machine Reset" button in the slide-down menu. Click the floppy icon in the top-right of the screen, which reveals two floppy drives.

You need to insert the disk in the bottom drive. Press the drive's "Eject" button, which opens a disk menu. Click "Insert," which opens a file browser. Select your disk image and click "Open." Then, with your virtual disk inserted, press Enter to select "Loader" from the Spectrum's boot menu. If the Loader program finds your disk image, it loads automatically, otherwise it prompts you to load a tape instead.

Loading memory dumps

Memory dump files (normally .Z80

files) are easy to start and load instantly. Click the hamburger menu button at the top-left of the screen, and click "Load State." Select your image file and click "Open."

If there is any glitching, try loading the image with an older 48K model.

Manually loading tapes

Original Spectrums don't have boot menus, so you need to enter commands in BASIC.

First, you need to know the name of your program. Load a tape as above, but look at the tape in the deck – on the label will be the name of the program in quotes, such as "TRAIL" for Trailblazer.

You can flick between programs with the "Fast-Forward" and "Rewind" buttons, which display different programs on the cassette label.

Power on your machine if you haven't already done so, and at the BASIC prompt, press J, which brings up the Load command. Enter the name of your program in quotes, but do not press Shift! The "character will appear, but the ' won't. If you have entered the command correctly, your tape will load as soon as you press "Play." ■

Find software

The Spectrum library is enormous and you will have no trouble finding software. Leaving alone dubious ROM sites, <http://archive.org> has plenty of titles, including cover tapes. Cover tapes are an incredible source of free games and often have exclusive content.

For anyone looking for new Spectrum games, a selection of modern titles are available at <http://zxonline.net>, <http://playonretro.itch.io>, and www.retroworks.es.

For an extensive back catalog, nothing beats <http://worldofspectrum.org>, which seems to take care in only allowing games that are either abandonware or free to distribute, and includes magazine articles, books, user manuals, and more.



Resident Evil 4 VR port has dual-wielding and will release this year

Capcom has announced a VR port for *Resident Evil 4*, releasing exclusively for Oculus Quest 2 later this year. It's not just a simple port: The most obvious change is that the third-person horror now plays in first-person, but along with the perspective shift comes some necessary VR enhancements: your weapon inventory is now strapped to Leon's body so, using the Touch controllers, you'll need to unholster and re-holster weapons just like you would in real life. You can dual wield separate weapons too, which is probably the biggest departure this port features compared to the original.

Traversal options are fairly exhaustive: you can still move using a Touch controller's analog stick, but the port also features teleportation movement and support for room-scale movement. Also, 4,500 textures have been "repainted or had their resolution increased," while character animations and cutscenes are all true to the original.

Cyberpunk 2077 has sold 13.7 million copies

Cyberpunk 2077 had a disastrous launch on PS4 and Xbox One, but it has still proven hugely lucrative for CD Projekt Red. The open world sci-fi RPG sold 13.7 million copies in 2020: a figure that doesn't include any sales made in the new year.

That's according to a financial report issued by CD Projekt, which also confirmed that more than half of those sales were for PC and Stadia. That makes sense, as the PS4 version of *Cyberpunk 2077* is still unavailable to purchase digitally, even after several title updates designed to improve performance on that console. It's unclear when that will be available again – or when *Cyberpunk 2077* will resemble the game that was marketed.



GAMING NEWS

Apex Legends studio is working on a new IP

It's going to be created "from scratch".

The studio best known for *Apex Legends*, *Titanfall* and *Jedi Fallen Order* is working on a brand new game. According to new job listings on the Respawn Entertainment website, the studio is kicking off a "new IP from scratch." That's good news for fans of the studio who might have worried that it would be eternally stuck on a game-as-a-service treadmill thanks to the success of *Apex Legends*.

The job listings don't reveal much else about the project, except that the successful applicant will help the studio "pioneer new ways to enable 'adventuring until the heat death of the universe.'" Hyperbole, or a hint at a possible *No Man's Sky*-esque infinite universe? We probably won't find out for years to come.

Battlefield 6 set to be the biggest in the series

It'll feature matches with more players than ever before.

Battlefield 6 is expected to release by the end of the year, and while publisher Electronic Arts has yet to formally announce it to players, it's promised again and again to investors that it's happening. Now general manager of DICE Oskar Gabrielson has dropped a few more hints about the project, which follows 2019's poorly received *Battlefield 5*.

"We're in daily playtesting mode right now: polishing, balancing, and making the best possible *Battlefield* game we can," Gabrielson said in April. "I can tell you it is a bold step. It has everything we love about *Battlefield* – and takes all of it to the next

level. Epic scale. All-out military warfare. Crazy, unexpected moments. Game-changing destruction. Massive battles, packed with more players and mayhem than ever before. All brought to life with the power of next-gen consoles and PCs."

Gabrielson also confirmed that it's the biggest *Battlefield* instalment yet in terms of the talent on deck: DICE, DICE LA, Criterion and EA Gothenburg are all collaborating on the project. Meanwhile, studio Industrial Toys is working on a *Battlefield* mobile game scheduled to launch next year.



Activision shares a *Call of Duty: Warzone* cheating update as permabans near 500,000

Over 475,000 players have been permanently banned in *Call of Duty: Warzone*.

Activision has released an update on its *Call of Duty: Warzone* anti-cheat progress, detailing how many permabans have been issued and how the team roots out cheaters.

According to the official *Call of Duty* blog, over 475,000 players have been permanently banned from *Call of Duty: Warzone*. The latest ban wave, which crashed onto Verdansk's shores on April 12, was the seventh large-scale ban since this February alone. Activision states that its security and enforcement teams issue bans daily "to individual offenses or repeat offenders."

Activision is also cracking down on cheat providers and resellers, or people who create accounts, farm them, and sell them at a premium. The developer has banned 45,000 "fraudulent, black market accounts used by repeat offenders" and is making sure those cheaters won't be able to move to alternate accounts. Activision even issues hardware bans against repeat "or serial" cheaters.

Call of Duty: Warzone is a popular target for cheaters and exploiters, so it's nice to see Activision is working hard to make the game more fair.

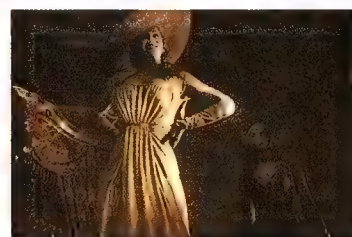
Animal Crossing: New Horizons player discovers Nook Phone hack to store DIYs

Sometimes, they're just not worth selling for 200 bells.

An *Animal Crossing: New Horizons* player has discovered a clever way to store the DIY recipes they don't want anymore.

According to a post in the game's Subreddit, *Animal Crossing: New Horizons* DIY recipes can be stored in the Recycle Box that's located in Resident Services – ready to be taken by secondary players or swapped with visitors. It isn't as easy as just placing the DIYs into the bin, however, as, just like with home storage, the DIYs can't be transferred via players' pockets.

Instead, players can send them to the recycle box by using the 'request cleanup' option in the Island Designer app via their Nook Phone. To do this, players need to place any DIYs they want to store on a table somewhere outside and access the app while standing next to it. It's important to remember though that any trees or shrubbery near players when they request a cleanup will also be wiped out, but won't end up in the recycling box.



Resident Evil Village leaker claims new mode will randomise enemies and items

The new claim comes from storied leaker Dusk Golem, who has a track record of accurately leaking *Resident Evil*-related information ahead of time. They reveal that they've heard talk of Capcom developing an experimental difficulty mode for *Resident Evil Village*, which would randomise every item in the game, and every enemy that protagonist Ethan faces over the course of the adventure.

Latest *Call of Duty: Warzone* patch adds DLSS support, finally

Also in *CoD* news, at long last DLSS support is here, announced in the patch notes for *Warzone Season 3*. DLSS, which stands for Deep Learning Super Sampling, is Nvidia's tech that provides performance boosts at high-resolution. You'll need a GeForce RTX card to try it out, and can expect a performance jump of up to 70 percent. ■

GAME REVIEWS

'TIS THE SEASON TO BE GAMING MADLY



\$69.95 | PC, PS4, Switch | bit.ly/31SUyoX

Spacebase Startopia

Manage a space station fuelled by nostalgia.

Realmforge Studios' *Spacebase Startopia* is a homage to one of my favourite management games. More than an homage, really, as it lifts pretty much everything from the original *Startopia*, even the name – it's more like an unofficial remake. After two decades of waiting, I should be happy to return to my donut-shaped space station, but instead I'm conflicted. Hewing so closely to the original also emphasises the ways in which it misses the mark, and some of the new additions leave a lot to be desired.

Thankfully, *Spacebase Startopia* is still capable of being charismatic, full as it is with aliens and sci-fi oddities. Sometimes I'll even follow my diligent little droids around as they travel all over the station delivering crates and cleaning up after the dirty organics. Even the bins have a bit of personality, as they're actually robots who drop off their gross cargo at the recycler once the droids have filled them up. They have very

serious faces and I love them.

With your station teeming with life, the three-level system proves to be a boon. The donut is split into sections, separated by bulkheads that can be opened for a fee, and three specialised decks. There's the sub deck with all your essentials, like berths, medical centres and factories; the fun deck where your visitors can let their tentacles down; and the bio deck, where resources grow and visitors can hang out.

The deck system was one of *Startopia*'s defining features and works just as well here. It splits the vast station up into chunks, and means you're never staring at the same stuff for hour. So when raiders are killing people on one deck and won't take a break just because you're busy trying to stop everyone from suffocating on another, that bit of distance makes it easier to prioritise.

Speaking of raiders, the fights sure do suck. It doesn't matter if it's pirates or monsters popping out of alien cocoons, combat is

the least entertaining aspect of the job. Managing your security bots and mechs mostly amounts to just clicking on the thing you want to kill... and that's it. Each class of mech also gets one unique ability, but that feels like overkill for encounters this shallow.

Along with invasions, other random events and time-sensitive choices crop up that offer more compelling management wrinkles. One of these events even taught me a valuable lesson: maybe it's OK to let a plague take root in your station if you're also in the business of curing people.

Management games have developed a lot over the last two decades, offering so many ways to build on *Startopia* instead of cloning it. I guess living in the past isn't such a good thing after all. But it can be fun to visit for a few days.

FRASER BROWN

A missed opportunity to meaningfully build on a classic, but it's still an entertaining game.

★★★★☆



\$29.99 | PC, PS4, XB1 | yakuza.sega.com/yakuza6

Yakuza 6: The Song of Life

Not a major departure from its predecessors, but still finds its own rhythm.

This is Kazama Kiryu's final game as protagonist – the end of a story that has played out over hundreds of hours across six previous games. Which is to say, if you're new to the series – or have only dipped your toe into a handful of them over the years – come back to this one later, when you've fallen a bit deeper down the rabbit hole.

After an in media res opening to set the tone, you're treated to a lengthy sequence that follows on directly from *Yakuza 5*'s semi-cliffhanger ending. A lot of the opening hours are spent slowly moving the pieces into place – dealing with the fallout and ramifications of *Yakuza 5*, and getting characters ready for the drama of the finale. The upshot is this: Kiryu, arrives in Onomichi – a port city in Hiroshima – with a baby in tow.

While you'll still spend plenty of time in Kamurocho – both in the story and as the de facto hub for minigames – Onomichi is both the heart of *Yakuza 6*, and a statement of intent. Where Kamurocho has karaoke, old Sega arcade machines, a cat cafe, and a new gym that lets you train your skills, Onomichi is smaller, quieter and more rural. It's a close-knit community that Kiryu has to work hard to crack, and is sparse with its distractions.

Onomichi's prominence sets *Yakuza 6* apart from its predecessors, offering a change of pace that gels well with the story being told. As Kiryu works to enamour himself to the locals, he falls in with a small-time yakuza family – a loveable bunch of losers whose hearts are nevertheless in the right place. It's a reprise of *Yakuza 3*'s setup, but one that offers a contrast to the destructive political dealings of the clans that threaten to once again tear down everything Kiryu cares about.

Yakuza 6 isn't the best game in the series, but it's definitely a deserving part of it, and well worth playing... at least when you're ready.
PHIL SAVAGE

The setting proves that the series still has some tricks.
★★★★☆



Free | PC, Mac | bit.ly/SuperRaft

Super Raft Boat

Keep your head above salty water.

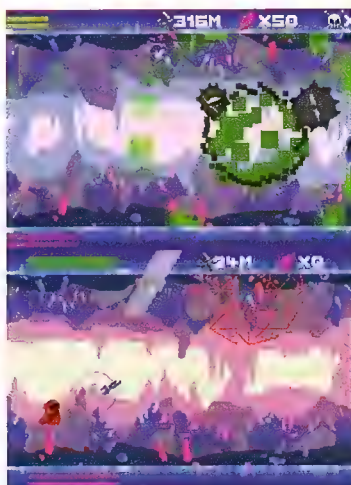
Build your own dungeon in the hectic *Super Raft Boat*, which takes place on the open sea – a terrible place. You extend, and repair a raft by plonking down endless bits of driftwood, while soggy terrors including sharks, fish and ghosts advance relentlessly towards you.

Your main method of defence is, naturally, a gun. Shoot the gulls and leaping fish before they can take a bite from you. Kill the sharks before they can chomp on your raft, tearing chunks of the floor out of your floating dungeon.

There's not a lot of land in it. Instead you have your raft: a hodgepodge island that's constantly growing and shrinking, as you build and the sea beasts tear it to bits. Space is at such a premium on your raft that you feel every piece of damage keenly.

Super Raft Boat has a small scope: there is only one boss fight, and no persistent unlocks other than the two bonus characters and a few skins and weapons. Even so, it offers a few good hours of gaming.
TOM SYKES

A small but perfectly formed roguelike that offers good enough gunplay and nail-biting raft management.
★★★★☆



Free | PC, Mac, Linux | bit.ly/3uOCGYI

Miska's Cave Grinding Crystals.

In endless runner *Miska's Cave*, you can also endlessly run on the ceiling, by bounding gracefully from the bottom to the top of screen. The game's rabbit-like hero is more acrobatic than Mario, even before you unlock the double and triple jump, which let you switch direction while the bunny is in mid-air.

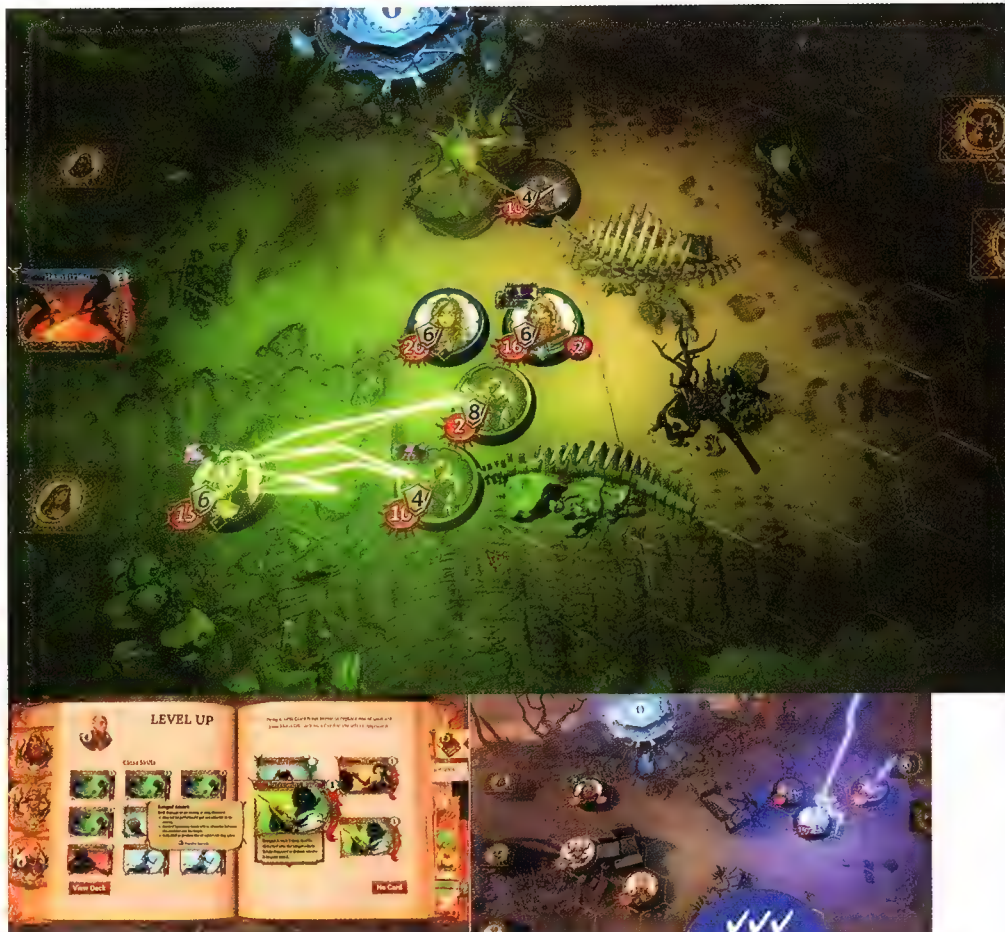
This athleticism gives *Miska's* a different flavour from other endless runners, which tend to focus on pits and obstacles to trip you up. *Miska's* is all about leaping, and all about its enemies, which come in waves and fly menacingly towards you. A quick slice is all it takes to knock them back and eventually kill them, but getting the timing right is another matter. *Miska's Cave* is quick: runs can be over in a matter of seconds, depending on how unlucky you are in the random drawing of enemies.

The game only really becomes fair once you've ground (grinded?) to embiggen your health. But beneath that issue there lies a nifty, rewarding runner about an acrobatic rabbit.

TOM SYKES

Blistering tough with a heavy reliance on essential upgrades to make progress.

★★★★☆



\$22.95 | PC, PS4, XB1, Switch | whatboy.com/game

Trials of Fire

An irresistible card-based roguelike.

Set in a blighted fantasy land, *Trials of Fire* sees you pick a trio of adventurers from an eventual pool of nine, before embarking upon a series of set quests across procedurally generated maps. Between you and your key objectives are regular points of interest, ranging from small settlements to ancient ruins, prowling monsters and spooky forests. Encounters are initially presented in journal format, with the game describing the situation before offering a range of choices. Sometimes these choices require a skill check that results in a reward if successful, or damages your characters if you fail.

Other times, your decisions will trigger a fight. What's immediately striking about *Trials of Fire* is how good the combat feels. When you drag out a ranged attack to target an enemy, an arrow flies out from your counter and thuds into your opponent, causing it to skitter on its space like a spun coin. When a character is killed, their counter bursts like a grenade, scattering shrapnel across the board. Yet this isn't what makes *Trials of Fire* special. That would be how cards simultaneously act as abilities and a resource.

By default, playing a card requires you to spend a resource known as willpower. There are a handful of cards that generate willpower, such as Advance, which also enables you to move forward. But the primary way of acquiring willpower is to sacrifice cards in your hand. This pool can be drawn from by all three party members unless you're using willpower for movement, in which case the sacrificed card must come directly from that character's deck.

Balancing survival with progress is one of the game's main challenges, especially since reaching a quest objective usually triggers a tough boss fight that will test your affinity with your deck. If your party gets wiped out, the quest is over. This can be a little galling, especially if you're near the end. But most quests are designed to be completed in two to four hours.

RICK LANE

Trials of Fire's list of features may read like a videogame word salad, but the result makes for a fine RPG feast.

★★★★☆





\$44.99 | PC | totalwar.com

Total War: Rome Remastered

Making an old game palatable again.

Rome: Total War is a classic in the series. It struck the perfect balance between being a game and being an exercise in history. *Total War: Rome Remastered* brings back what I'd call the first great *Total War* game for the modern era, updating much of its outdated UI and scaling it up to 4K and widescreen displays. It'll be a trip down memory lane for those who loved the original and a more palatable experience for modern *Total War* lovers.

As a remaster, a lot of attention is going to be given to how it looks and sounds, but what you really get out of this remaster is how it plays. The old *Rome: Total War* didn't always play well with modern hardware. The new one does quite well. That's not to say the graphics or sound are lacking. The music especially is much higher quality than the old game, and whatever magic was worked there has revitalised one of the best soundtracks of an entire era. The graphics? Well, it's a remaster, not a remake.

What hasn't changed with age is how good the *Rome: Total War* strategic layer is, and the

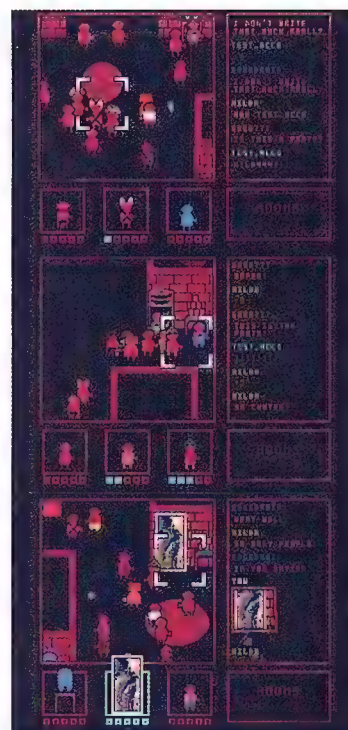
revamped campaign map does a lot to highlight the simple-yet-deep empire management. The early *Total War* system of settlement population does all the strategic heavy lifting, asking you to choose between upgrading infrastructure for population growth and long-term income. The choices are well-served by a new UI outlining the building tech tree. Adding to this is a new set of screens for the world map, letting you get access to information about the campaign world state at a glance that could be a chore in the original *Rome: Total War* – which settlements are biggest? Where are the resources? Who do I border?

It's a large-scale strategy game that for its time was huge but is pretty small by modern standards. It has fewer unique factions, even with unplayable ones unlocked by the remaster, than modern games. The simplicity ends up being a real strength.

JON BOLDING

A competent remaster of a great strategy game, but it can't compete with its modern heirs.

★★★★☆



Free | PC | kultisti.itch.io/roborazzi

Roborazzi

Snapping celebs in nightclubs.

In *Roborazzi*, you are a robot paparazzi, and it's actually a pretty stressful job. For one thing, you can't stop. In every nightclub-set level, you're given a list of targets to take photos of (funkily dressed partygoers, or sometimes parts of the scenery). However, as your character won't stop moving – as you shunt them around the gaff with WASD – it can be tricky to locate your mark, and to keep them in shot while you work your camera magic. Take a pic of the wrong person, or stumble into the shot yourself, and you'll lose a chunk of health.

Because a roborazzi charges its batteries by taking photos of celebrities, the other wrinkle is your dwindling life bar, which depletes as time goes on. While you recover health for every successful snap, this is still a challenging game that I had to restart a number of times.

While it has your attention, this is a novel, fairly stressful pixel hunt that takes its robot-paparazzi theme and does it a certain amount of justice.

TOM SYKES ■

A short dose of nice gaming entertainment.

★★★★☆



DEVELOPER HUMONGOUS ENTERTAINMENT PUBLISHER IN-HOUSE RELEASED 1996 WEB humongous.com

Pajama Sam: No Need to Hide When it's Dark Outside

Revisiting the adventure games we grew up on. By James Davenport

I'm not afraid of the dark. I'm not! But I am afraid of what PC gaming would look like without *Pajama Sam*. A whole generation of PC gamers grew up after the heyday of adventure games, but were too young and oblivious to notice the rapid descent of a genre. All kids knew was the computer desk, a treasure trove littered with old CDs, many of which had a game from Humongous Entertainment tucked away somewhere. And it was scratched to hell probably, sending CD-drives into whirring, heaving fits – working nevertheless. Playable cartoons. That's what we thought of them, and *Pajama Sam's* big adventure in a surreal nighttime world hidden in his closet might've been the best of the bunch.

In *Pajama Sam: No Need to Hide When it's Dark Outside*, you take on the role of Pajama Sam himself, finally confronting the

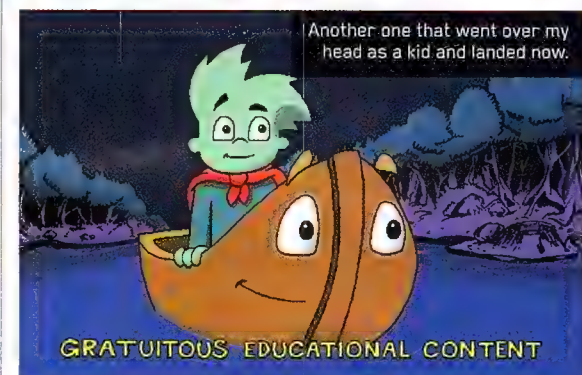
darkness hiding away in his closet. As a kid, he's scared of the stuff, but it's not as easy as stowing away the concept of darkness into a lunchbox like Sam hopes. Once in the closet, the kid trips and falls into a Pee-Wee-Hermesque realm of darkness where everything has a face, from trees to meat grinders. After the transdimensional fall, Sam loses some key darkness banishing items, so your task is to find them and march up to the tip-top of a spooky treehouse to finish the fight off.

From here it plays like an abbreviated LucasArts point-and-click adventure, and for good reason. Ron Gilbert, of *Maniac Mansion* and *The Secret of Monkey Island* fame, teamed up with producer Shelley Day to create Humongous Games in 1992, a name contributed by none other than LucasArts cohort Tim Schaefer. Writer of

The Secret of Monkey Island and its sequel *LeChuck's Revenge*, Dave Grossman, came on to pen *Pajama Sam*, so it retains a familiar mix of visual gags propped up by a simpler, but equally goofy form of adventure game logic in the puzzles.

Without a paddle

What I mean: to get across a river, Sam needs to convince a boat that the rumours aren't true, wood doesn't sink. So you fish a plank out of a creek, framed and animated so prominently in the scene that no kid would miss it, and toss it in the water near the beached boat. Its mind blown, the boat leaps into the water and offers to take Sam wherever he pleases – but the moment you leave the scene, the plank, still floating there in the foreground, quietly sinks. I barked like a dog, a joke that flew over my head years ago



smacking me in the dome all these years later. That boat's going to fucking drown.

The art and animation still stand up, though I remember it looking nicer on a fuzzy CRT. They had a way of blending the low-res pixelated scenes into something that more mirrored what I was watching on TV every Saturday morning. Even so, Sam never stiffly tiptoes between scenes. He springs up and leaps and dives, an elastic little guy with almost no repeating keyframes. An entire room of living furniture has an infinite dance party, a talking mincart takes Sam on a ride through a mountain on a physics-defying track, Sam liberates carrots from the kitchen in a cute musical number – *No Need to Hide* is lovely in motion.

Pajama Sam knows kids aren't going to make it through the space between narrative beats, the time in every adventure game where you're stuck staring at an idle screen, pixel-hunting for a missed object or interactive piece of scenery. Click on nearly any part of a screen and something will happen. A tree



Big Buds Meet the original Humongous squad



FREDDI FISH

Banished ghosts and caught hogfish rustlers. Flipping loved solving cases.



PUTT PUTT

Terrifying. First game: Parade. Second game: Moon?!



SPY FOX

Aimed towards older kids, 007 parody. Peak cheese humour.



FATTY BEAR

For the youngsters, a body-shamed failure. One game. Sad. Do not hug.

root will grow a face and moan about how they didn't have videogames back in their day. A pizza will fall out of the sky onto a tennis racket. Flowers will play Patty Cake. A gorilla will appear in a smudge of darkness, whip out a banana, and have a quick snack. Sam doesn't acknowledge any of the animations, a bizarre purgatory between the reality of the player and the fiction taking place – but as a kid, it was a damn cartoon buffet. There are dozens of tiny, bespoke animations to stumble over on the way to the

next item or clue, and nearly every one of them is funny, or just so odd you can't help but laugh. It's honestly the level of interactivity I would've welcomed in adventure games designed for any age. A simplified verb set and a reactive environment go a long way in preserving patience.

Sam's a lovable kid, too, in large part thanks to Pamela Adlon's enthused performance. You'd probably recognise the voice instantly. Adlon's also behind one of the greatest animated characters of all time: Bobby from



This looks like a job for... a child!

King of the Hill. More recently you might've seen her on the excellent series *Better Things*, where she writes, directs and plays the lead. Coincidentally, I started watching it the same week I returned to *Pajama Sam*. An odd thing, to hear the same voice go from being scared of the dark to making jokes about going through menopause. Humongously entertaining, indeed.

Pajama Sam had to be. A single adventure game had to sustain four kids, minimum, for a couple weeks. I met most of my friends at Julie's, someone that kindly watched half the kids in the neighbourhood. Miraculously, she gave us free rein on the computer. We played together, bunched around the computer after school almost every day. Back at school we discussed theories in the sandbox and spouted epiphanies when our swings passed. We should use the doorknob on the door without a doorknob! Baby geniuses.

We never did crack the whole case on our own, stuck trying to find where to read the water meter in the mines in order to win a quiz

show hosted by living doors. While *Pajama Sam* never got to rubber-with-a-pulley-in-the-middle levels of convoluted, it was still quite difficult to parse for our developing minds. Kids are pretty dumb, turns out.

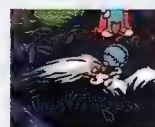
The bottom dropped out when my buddy Brian's family got internet and we discovered GameFAQs. The local adventure game market crashed overnight for most of the neighbourhood. We ripped through the whole Humongous catalogue in about a week at Julie's. I lost a family that day. But I also found a new one in the CD bargain bin. The LucasArts Archive collections probably changed a lot of lives – \$20 for *Day of the Tentacle*, *Sam and Max Hit the Road*, and a handful of other LucasArts games would do the same to anyone. Revisiting *Pajama Sam* has been a heartwarming reminder of my own PC gaming origins, and I'm sure I'm not alone here, which makes it an easy recommendation to pick up and play again no matter your age. It's a breezy two-hours for my big adult brain. Join me: humiliate the memory of your stupid kid self.



Sam in some convincing tree cosplay.

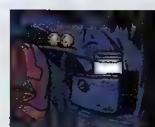
Click tricks

Odd stuff you'll see clicking around a scene



01 OLD MAN ROOTS

An old man rambles about life back in 'his day'.



02 COOKIES N MILK

Cookies appear and commit suicide by milk.



03 BASEBALL

Click the baseball and bat for a tiny minigame.



Classic LucasArts-style
adventure game scene design.

"I expected to get frustrated and bored with Pajama Sam, to play purely for the nostalgia, but I was delighted throughout, even if the narrative is literally: the dark isn't that bad."

Luckily, most Humongous Entertainment games are easy to find and play today, thanks to Nightdive Studios, the studio responsible for keeping dozens of old games working on modern machines, including the upcoming remake of *System Shock*. I expected to get frustrated and bored with *Pajama Sam*, to play purely for the nostalgia, but I was delighted throughout, even if the narrative is literally: the dark isn't that bad. Believe it or not, I've already overcome my fear of the dark. I can sleep in total darkness and not wet the bed once all night. Sure, I have to pay bills now and my brain eats itself in new ways, like fearing the death of my parents or the collapse of a state's entire infrastructure or the incoming eco-apocalypse, but *Pajama Sam* helped me nip that whole dark thing in the bud



for me 25 years ago. I'm actually very grateful.

Bothered by bugs

The only major caveat weighing down my hot air balloon ride into the past are a couple bugs present in the Steam version of *Pajama Sam*. Some scenes don't always load in crucial interactive objects properly, or at all. A late game puzzle requires Sam to find some oars in order to fish something out of the water. They're normally propped up on a wall in a room with an organ and a talking bust, but in my instance? Nothing. No oars, even though I could climb the organ and leap on the chandelier to initiate an interactive swinging sequence in which the oars snap into existence.

Worse, though, is that even though I could see the oars, I

couldn't ever finish the swinging minigame. Sam would reach out, I would time my clicks to give him momentum, but the oars were forever just out of reach. A quick Google search confirms little game-breaking bugs like this are somewhat common, so keep that in mind before dipping back in. If it's any assurance, it's a short game already, and you can jam escape to skip literally any animation. I got back to the same sequence, unbugged, in about ten minutes.

I was adamant about seeing the game through, bugs and all, so maybe Sam's got some staying power. If you're a mother, father, uncle, aunt, babysitter – whatever, humour me. Plop a kid in front of *Pajama Sam*, see what happens. Kids are growing up with touch devices, so the point-and-click interface should be pretty easy for them to figure out. Tell them you have a new cartoon for them to play, say it's from the creators of 'Baby Shark' or whatever. Lie to them. This is important. Because if they like it, *Quake* is right around the corner. ■



Raspberry Pi turns Nerf Gun into *CoD* controller

YouTuber gets creative by using toy gun as PC input.

Coder and YouTuber Alfredo Sequedia posted a video in April of his project to turn a *Fortnite* Nerf gun into a controller for *Call of Duty* on PC. Sequedia connected a smartphone with custom code that allowed it to output data from its accelerometer to a Raspberry Pi that translated the gun's movement into mouse controls in real time. He also fabricated some custom buttons that were built into the rifle grip and mapped them to relevant keyboard keys to control everything from the toy gun. Sure, the cabling wasn't the neatest we've seen and there was no shortage of lag, but it worked well enough to play.

dwight schrute

Overview Activity Friends Rep

Profile Info

Steam ID	augfix
Reputation	NEUTRAL
Public profile	✓
Country	United States
Steam years	12
Donator	✗
Friends	11 / 2000
Status	Offline

Level stats

836 Badges (28 Foil) • 1,340,648 XP
Estimated Cost \$2,653.06
Next Level Cost \$5.90
World Rank #638 (0.1%)
Region Rank #77 (0.1%)
Country Rank #54 (0.1%)
Best World Rank #100

Playtime stats

Total Playtime	23,465 hours
Avg. Playtime	42 minutes
World Rank	#6,593 (0.4%)
Region Rank	#788 (0.4%)
Country Rank	#566 (0.4%)
Best World Rank	#14

Games stats

24K	32,823 Games
Estimated Cost	\$252,495.60
World Rank	#1 (0.1%)
Region Rank	#1 (0.1%)
Country Rank	#1 (0.1%)
Best World Rank	#1

Featured Steam badges

#	Badge	Level	XP	Last crafted
1	2019: Steam Grand Prix	6,328	632,800	28 jun 2019
2	2020: Steam Awards	1,408	140,800	16 jan 2021

Most played games

Game	Playtime
Overwatch	1,340 hours
Team Fortress 2	1,340 hours

Steam now works for the three people that own over 25,000 games

It kept crashing before.

In April Steam released a beta client update that would "Fix a possible crash for users with around 25,000 or more games"; an announcement that naturally caused some to wonder how many people could own that many games. Apart from the stash adding up to an investment somewhere in the ballpark of a quarter of a million dollars (if games cost on average \$10 a pop), we're not sure how many of them you could reasonably expect to play. *Kotaku* reckons you could get through them in three years if you never slept and played a new one every hour, but it'd take you 47.7 years if you played two a day, every weekday.



Apple's new Magic Keyboard has an Emoji button

GET ALL YOUR EMOJIONS OUT WITH A SINGLE KEYSTROKE.

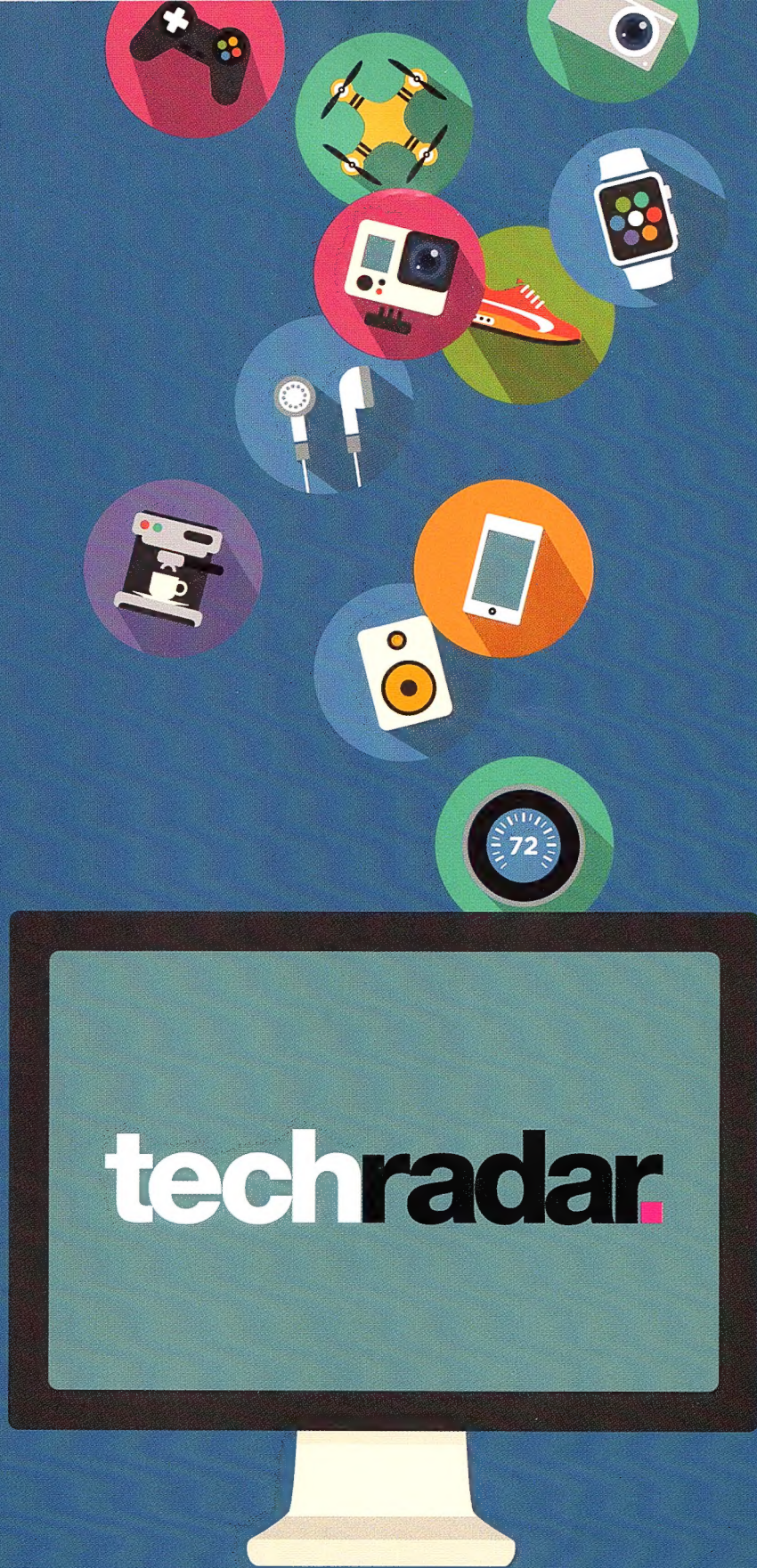
While most people are getting excited about the Touch ID fingerprint reader landing on the new iMac keyboard for the first time in April, there's another novel addition to the lineup... an emoji key. While it's perhaps not quite as brazen as the touch bar which, let's face it, all the whippersnappers use primarily for displaying their fave custom pictographs, Apple did decide to place it over the function key. Who needs F12 when you can just send fire to your bae? Between that and the new dictation buttons, you can basically do away with all those redundant QWERTY keys.



Asrock make first mechanical mobo

FIRST MOVING PART ON A PCB RUNS LIKE CLOCKWORK.

Asrock has long used cogs as a design symbol of their technical prowess, but never before has that icon actually moved. In what's perhaps the most revolutionary advancement in exorbitant mobo frills since the inclusion of RGB, Asrock's latest Z590 Taichi motherboard comes with a mechanical cog that actually uses a motor to spin. Sure the single rotating cog is the sum total of this mechanical milestone, but it'll provide hours more entertainment while gazing longingly at your PC. The only thing we're more excited about is the next iteration which may feature two interlocking cogs rotating. What a world. ■



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